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Memoirs of the Museum of Comparative Zoölogy

AT HARVARD COLLEGE.

Vol. X. No. 1.

REPORTS

ON THE

RESULTS OF DREDGING,

UNDER THE SUPERVISION OF

ALEXANDER AGASSIZ,

IN THE GULF OF MEXICO (1877–78), IN THE CARIBBEAN SEA (1878–79), AND ALONG THE ATLANTIC COAST OF THE UNITED STATES (1880),

BY THE

U. S. COAST SURVEY STEAMER "BLAKE,"

Lieut.-Com. C. D. Sigsbee, U. S. N., and Commander J. R. Bartlett, U. S. N., Commanding.

XXIV. Part I.

Report on the Echini. *By* Alexander Agassiz.

(Published by permission of Carlile P. Patterson and J. E. Hilgard, Superintendents U. S. Coast and Geodetic Survey.)

WITH THIRTY-TWO PLATES.

CAMBRIDGE:

Printed for the Museum.

September, 1883.

INTRODUCTION.

The Preliminary Reports on the Echini of the Blake Expeditions for 1877–78, for 1878–79, and for the summer of 1880, were published in Vol. V., No. 9, Bull. M. C. Z., and Vol. VIII., No. 2, Bull. M. C. Z. In the former Report will be found all the Stations occupied in the Gulf of Mexico and Straits of Florida; in the latter, the Stations explored along the West India Islands and the Atlantic coast of the United States. I give in this Report, therefore, only principal localities in sufficient number to indicate the geographical range and bathymetrical distribution of each species as determined by the dredgings of the "Blake." In the Report on the Echini of the Challenger Expedition I have given a list of the bathymetrical and geographical distribution of all the species of Echini then known, including the species collected by the Blake Expeditions. The Preliminary Reports on the Deep-sea Echini, collected by Mr. Pourtalès off the Florida Reefs, were published in the Bull. M. C. Z., Vol. I., No. 9. The final Report was incorporated in Part II. of the Revision of the Echini under the name of "East Coast Echini," Ill. Cat. M. C. Z., No. VII. Mem. M. C. Z., Vol. III., 1872–74.

The importance of the collection of the Echini brought together during the cruises of the "Blake" is well shown by a comparative statement of our knowledge of the Caribbean Echinid Fauna before and after the explorations undertaken under the auspices of the United States Coast Survey.

There are now known eighty-three species of Sea-urchins from the Caribbean Fauna. Of these, eleven were added by the dredgings of Count Pourtalès in the "Bibb" and "Hassler," nineteen were discovered by the "Blake," and thirteen species previously known from other districts were dredged for the first time in the Caribbean and adjoining seas by the Coast

Survey Expeditions, so that the list of species has been more than doubled by the dredgings made since 1876.

In consequence of the great delay in preparing the illustrations of the more minute structure of the Salenidæ, the Echinothuriæ, and many of the less well known Spatangoids, the concluding Part of this Report will appear on their completion.

The details of the geographical distribution of the Echini of the "Blake" having already been given in the Preliminary Reports (Bull. M. C. Z., Vol. V. No. 9, 1878, Vol. VIII. No. 2, 1880), to avoid repetitions I merely refer to the previously published records, as well as to the list of the dredging stations occupied by the "Blake" (Bull. M. C. Z., Vol. VI. No. 1, 1879, Vol. VIII. No. 4, 1881). These give the position, the depth, the temperature, and the character of the bottom. On the completion of the Reports by the different specialists, who have kindly consented to work up the collections of the "Blake," including the examination of the bottom samples, I hope to make a revision of the geographical and bathymetrical distribution of the various groups, so as to give a good picture of the animals associated at the principal localities which make up the Fauna characteristic of certain well-defined regions. Nothing can be more different, for instance, than the animals found associated on the rocky bottom along the southern slope (in deep water) of the Florida Reef, on the Pourtalès Plateau, with its predominance of Corals, Rhizocrini, and Starfishes, from those found in the calcareous ooze of the trough of the Gulf Stream (Lamellibranchiates, Holothurians, &c.); and again from the association of the masses of Gorgoniæ, Saleniæ, and Terebratulæ, off the north coast of Cuba, brought up in a single haul of the trawl. Nor can there be a greater contrast between the inhabitants of the Pteropod ooze in deep water off the west end of Santa Cruz, with its preponderance of Phormosomæ, of Asthenosomæ, and Hyalonemæ, and those of the forests of Pentacrini and Gorgoniæ, and the accompanying Comatulæ and Ophiurans, living in such abundance on the windward coast of St. Vincent.

We may contrast, again, the deep-water Fauna off the Tortugas, in the coral ooze, mainly made up of a most remarkable association of Fishes

and Crustacea, with the hauls in deep water, at special localities, made up entirely of thousands of specimens of single species, either of Ophiurans, of Echini, of Comatulæ, of Crustaceans, or of Gorgoniæ.

Take again the bottom along the ridges between the West India Islands, or along the course of the Gulf Stream off the Carolinas, which are swept nearly clear of all animal life, and compare that to the rich and varied Fauna found at the same depths along the continental shelf farther north, and along the western shelf of the Windward Islands, on the lee side, in the Caribbean; or compare these Faunæ in turn with the mass of animal life, mainly composed of Gorgoniæ, of Calcareous and Horny Sponges, found upon the great plateau on the west of Florida and on the Yucatan Bank; there can be no greater contrasts within the narrowly circumscribed areas I have mentioned, all belonging to the West Indian Fauna taken as a whole. This clearly indicates great faunal contrasts in very limited areas, differing principally in the character of the bottom, and where the physical conditions, such as temperature, depending mainly upon currents and winds, are in striking opposition within comparatively moderate distances.

ALEXANDER AGASSIZ.

Cambridge, Mass., September 1, 1883.

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REPORTS

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Cidaris tribuloides Bl.

Off St. Kitts, 250 fathoms. Flanegan Passage.
Lat. 24° 44′ N., Long. 83° 26′ W. 37 fathoms.

* Dorocidaris Bartletti A. Ag.

Dorocidaris Bartletti A. Ag. Bull. M. C. Z., VIII., No. 2, p. 69, 1880.
Montserrat to Barbados. 88–398 fathoms.

Pl. II. Figs. 16–27.

At St. Vincent and at Martinique were first collected a number of remarkable spiny transversely banded radioles (Pl. II. Figs. 18, 19, 26, 27) similar to those of *Goniocidaris bispinosa*, and which I had already noticed in the earlier Preliminary Reports of the Blake Expedition for 1877–78. From Barbados a few specimens of Cidaris were dredged, showing these radioles to belong to a species of Dorocidaris differing from *D. papillata* and *D.*

* Species marked * were discovered by the "Blake."

Blakei in the shape of the plates of the abactinal system (Pl. II. Fig. 17). The ocular plates are in contact with the extremities of the large anal plates inserted between the genital plates; the other plates of the anal system are of a more uniform size than in the other species of the genus. In a specimen measuring 50 mm. in diameter, there are 7–8 primary interambulacral plates; these are covered by a comparatively coarse, irregularly arranged secondary granulation. The poriferous zone is somewhat flexuous, the furrows more distant, and the median ambulacral granulation finer, than in the other West India species of the genus. The ambulacral papillæ and those at the base of the primary radioles of *D. Bartletti* are nearly of uniform size; in *D. papillata*, those surrounding the radioles are somewhat larger, and in *D. Blakei* they are still more different, being comparatively much wider and flatter than the narrow ambulacral papillæ.

*Dorocidaris Blakei A. Ag.

Dorocidaris Blakei A. Ag. Bull. M. C. Z., V., No. 9, p. 185, Pl. IV., 1878.
Dorocidaris Blakei A. Ag. Bull. M. C. Z., VIII., No. 2, p. 70, 1880.
Off Havana, 175–450 fathoms.
Santa Cruz to Barbados, 163–270 fathoms.

Pl. I., Pl. II. Figs. 1–17.

This species (Pl. I.) is perhaps the most interesting of the recent Cidaridæ. Thus far the living Cidaridæ known have not shown any great or striking variety in the form of the radioles. With the exception of some of the recent species of the genus *Goniocidaris*, the radioles as a whole are characterized by their great uniformity, while among the fossils of the family the great variation in the shape and size of the radioles of some of the Jurassic and Cretaceous species is most remarkable. In the description of species of the recent Cidaridæ, it has not been unusual to lay great stress upon the differences noticed in the shape and ornamentation of the radioles. Comparative studies of recent and fossil types have shown the practice to be dangerous, and the discovery of *D. Blakei* plainly proves that hereafter we must proceed most cautiously in the determination of species from the characters of the radioles alone, no matter how strikingly they may appear to differ. Certainly, if the present species had been dredged without its two or three huge fan-shaped spines, it would have been unhesitatingly placed in the genus Dorocidaris, and been perhaps referred even to *D. papillata*, although there are differences in the coronal plates of the test and in the abactinal

system (Pl. II. Figs. 1, 2) which would undoubtedly lead to their being considered specifically distinct. Yet, if the isolated huge fan-shaped radioles had alone been dredged, radioles (Pl. II. Figs. 7–10) nearly identical in shape with those of the Jurassic *Rhabdocidaris remus* Des. (Phyllacanthus Br.) few palæontologists would have hesitated to refer them to that genus.

A comparison of the differences in the test of this species and of *D. papillata* shows that the coronal plates (Pl. II. Fig. 1) have a comparatively larger and more elliptical scrobicular area, surrounded by a single row of larger secondary tubercles; the tubercle and boss are much smaller, and the tuberculated spaces of the median interambulacral area are also narrower. In a specimen measuring 37 mm. there are 6–17 primary interambulacral plates, while in a smaller specimen of *D. papillata*, measuring 35 mm., there are 7–8 primary interambulacral plates. In the ambulacral areas the poriferous zone is nearly as broad as the median ambulacral spaces (Pl. II. Fig. 1), while in *D. papillata* it is narrower; the secondary ambulacral tubercles are also smaller than in that species. It also differs from *D. papillata* in having a smaller anal system, but this is covered by a larger number of plates inside the outer row (Pl. II. Fig. 2) than in *D. papillata*. The ornamentation of the radioles is the same on the long fusiform, or cylindrical, or the more or less fan-shaped radioles of the test (Pl. II. Figs. 3–10); these figures show well the gradual passage from a long, sharp-pointed, cylindrical radiole (Pl. II. Fig. 3) to a huge fan-shaped radiole (Fig. 10), through the successive stages of Figs. 4–9, in which the radioles become little by little more flattened and spreading at the extremity. As the radioles become more fan-shaped, the rows of spinules are gradually changed into minute serrations, spreading more and more, and becoming somewhat less prominent towards the extremity, rows of smaller serrations being intercalated as the extremity of the radioles becomes more and more fan-shaped. The broad end of the fan-shaped radioles is sometimes slightly concave.

In the first specimens of this species, dredged by Captain Sigsbee, there were no radioles showing the intermediate stages here figured between the long, sharp, cylindrical radioles of Plate II. Figs. 3, 4, and such fan-shaped ones as are figured in Plate II. Figs. 9, 10. Enough has been shown from the examination of this species to show how little we are as yet able to determine among the Cidaridæ the value of either generic or specific characters. Before we can hope to make the much needed accurate revision of this family we need a large mass of material, especially

from the fossil species, in the way of spines associated with their respective tests.

When alive these Echini were of a brilliant vermilion color.

Among the specimens of *D. Blakei* there are a number without fan-shaped radioles; others, in which there were only one or two of the slightly flattened radioles similar to those of Plate II. Fig. 5; others again, in which there were a few radioles like those of Plate II. Fig. 7; and others, in which a few of the fan-shaped radioles took the extraordinary development we find figured in Plate I.

Dorocidaris papillata A. Ag.

For localities see Bull. M. C. Z., V., No. 9, p. 185, 1878; Bull. M. C. Z., VIII., No. 2, p. 70, 1880.

On our coast this species has been found by the "Blake" as far north as Lat. 32° 33′ N., Long. 77° 30′ W. Along the Florida reefs, in the Gulf of Mexico, and along the West India Islands, it is the most common sea-urchin found from about 100 to 300 fathoms. I have dredged it to a depth of 842 fathoms off the Grenadines.

* Porocidaris Sharreri A. Ag.

Porocidaris Sharreri A. Ag. Bull. M. C. Z., VIII., No. 2, p. 71, 1880.
Nevis, Barbados, 122–356 fathoms.

Pl. III., Pl. IV. Figs. 1, 2.

This species differs from its Atlantic congener, *P. purpurata* Wy. Th., in having a comparatively larger number of ambulacral plates, — no less than fifteen for the median interambulacral plates (Pl. IV. Fig. 1) in the largest specimen collected, while in a specimen of *P. purpurata* of nearly the same size there are only ten; the ambulacral granulation is also much finer, and the large areolar ring of comparatively large granules is flanked by smaller granules arranged in irregular lines parallel to the suture. We find no such arrangement in the coarse granulation of the interambulacral plates of *P. purpurata*.

This is a larger species (Pl. III.) than either of the other recent ones thus far known. The two largest specimens collected were males; a single small female, measuring slightly over an inch in diameter, shows that in this species, as in *P. elegans*, the genital openings are placed within the genital plates (Pl. IV. Fig. 2).

The abactinal system (Pl. IV. Fig. 2), which is but sparsely covered by papillæ, is remarkable for the size of the anal system, comparatively larger than in the other species of the genus, and for the elongate genital and ocular plates.

The primary radioles are smooth, and uniformly tapering; in one of the specimens, which was of a light greenish pink color when alive, the spines are white with a delicate brownish-pink base. In the other large specimen they vary greatly in shape, from the peculiar serrated, short, flattened spines, surrounding the actinostome, characteristic of this genus, to long, slender, cylindrical spines, straight, or sometimes slightly curved, equalling in length twice the diameter of the test, and finely fluted for the whole length, or to the shorter radioles, gradually becoming thicker towards the tip, with coarser fluting; we also find some spines with slightly cupuliform tips, as in Goniocidaris. The largest specimen measures fully 72 mm. in diameter.

* Salenia Pattersoni A. Ag.

Salenia Pattersoni A. Ag. Bull. M. C. Z., V., No. 9, Fig. 1, p. 187, Pl. V., 1878.
Salenia Pattersoni A. Ag. Bull. M. C. Z., VIII., No. 2, p. 72, 1880.
Off Havana, Caribbean, West Indies.

Pl. IV. Figs. 3–23; Pl. V.; Pl. VI. Figs. 18–23.

This is the most exquisitely colored of the living Salenidæ thus far known. When alive the test is of a light cream-color. The shafts of the primary spines are banded alternately with cream-color and brilliant vermilion, the colors being nearly equally divided. This coloring at first glance gives to this species very much the appearance of the Florida species of Cœlopleurus. The secondary spines are also cream-colored, separated at the base by dark violet belts, extending from the apical to the actinal system along both the median ambulacral and interambulacral lines. Similar dark violet lines separate the genital plates and the superanal plate from one another, the dark lines of the median ambulacra and interambulacra extending some distance into their corresponding genital and ocular plates. The primary spines are from three to four times in length the diameter of the test, and carry minute, sharp, irregular serrations; these are frequently worn off, the radiole then presenting a nearly smooth surface, slightly granular. These spines are remarkably uniform in their appearance, differing merely in length, and we do not find among them the great variation so characteristic of the primary spines of *S. varispina*, the only exceptions being the Porocidaris-

like spines found near the actinostome. The papillæ or secondary spines are long, with a rounded slightly concave extremity. The outer edge of the abactinal system and the median line of the ambulacral area are thickly studded with minute globular pedicellariæ. The plates of the abactinal system are covered by a coarse granulation; this towards the outer edge of the genital plates becomes minute sessile spines. The sutures between the genital plates, as well as the lines separating them from the abactinal part of the ocular plates, are deep. The anal system carries short, stout, pointed spines. None of the genital pores, with the exception of the madreporic genital, are very distinct; the madreporite consists of a few minute pores adjoining the large genital pore. The ocular plate opposite the superanal plate nearly touches the anal system, approaching it much closer than is the case in *S. varispina*.

In specimens measuring 12 mm. in diameter, there are usually from five to seven primary tubercles in the interambulacral area. The secondary tubercles, carrying the flat papillæ, are arranged vertically in open arcs round them; and these arcs, running together along the median interambulacral line, form two wavy vertical rows of tubercles, closely packed, which gives to the median interambulacral area a somewhat sunken aspect, as in Goniocidaris. The ambulacral tubercles, as in *S. varispina*, resemble in their arrangement those of Hemicidaris, forming two vertical rows; they are largest near the ambitus, diminish rapidly in size towards the actinostome, and more gradually towards the apical system. The largest ambulacral tubercles are not larger than the secondaries surrounding the primaries of the interambulacral area. The ambulacral zone is narrow; the pores are arranged in a slightly undulating line, following irregularly the outline of the primary plates in the interambulacral area. Smaller and larger specimens differ only in the size of the primary tubercles, those towards the actinostome increasing but slowly in size as the diameter of the test enlarges. The principal differences to be noticed are in the greater number of imbricating plates which cover the actinal membrane in the older specimens, as compared with the more simple arrangement of the plates and their smaller number in earlier stages. In younger specimens the five pairs of large buccal tentacles cover nearly the whole actinostome; they next become separated from the actinal edge of the test by a few irregularly arranged imbricating plates, and as the rows of plates increase they form also narrow zones between the pairs of buccal plates in extension of the interambulacral areas, until in the older

stages collected the pairs of buccal plates are quite distant. In the abactinal system the differences due to age are quite marked. The plates covering the anal opening are few in number, and comparatively large in the younger stages; with increasing size the plates become more numerous and relatively smaller, and carry from one to two minute tubercles. The granulation of the genital and ocular plates becomes also more distinct with increasing size, forming more or less regularly radiating lines; the outer edges of the plates of the genital ring become also somewhat indented, the inner edges of the ocular plates are grooved in the extension of the radiating lines of the granules of these plates. The gills of *S. Pattersoni* are stouter and less branching than the gills of *S. varispina*, and the few sphæridia noticed are remarkable for their small size and globular outline; one or two sphæridia are placed in the ambulacral areas close to the edge of the ocular plates.

Salenia varispina A. Ag.

This species, of which only a single young specimen had been collected by Mr. Pourtalès, has been found from Lat. 21° 36′ N., Long. 84° 5′ W., as far as Granada and Barbados, in depths of 334–1,200 fathoms. It is most abundant in depths between 400 and 600 fathoms.

For other localities, see Bull. M. C. Z., V., No. 9, p. 186, 1878; VIII., No. 2, p. 71, 1880.

Pl. VI. Figs. 1–17.

How far the obliquity of the axis of the apical system is a structural feature of sufficient importance to be considered a generic difference, it is difficult to decide. In Salenia we undoubtedly have in the asymmetrical arrangement of the plates of the apical system a feature somewhat prominently developed, which is found in all Echinoderms, and which is due to the original mode of growth of the plates of the embryo Echinoderm in a spiral curve. Traces of this are plainly to be seen in the unequal development of the genital and ocular plates throughout the group of Echini, in no one of which do we find the five plates either of the genital or ocular system symmetrically developed, or exactly symmetrically arranged in relation to a longitudinal axis. We find this in the apical system of the Palæchinidæ, the Echinothuriæ, the Cidaridæ, the Echinidæ, the Clypeastroids, and the Spatangoids, as well as in the asymmetrical test of all young Echinoidea; and perhaps we may trace the different degree of development of the five series of ambulacral and interambulacral zones throughout the group of Echini to such a primitive differentiation. As Neumayr has suggested, the appearance of the suranal plate in Salenia may not have the meaning or importance which has been attached to

it from a morphological point of view when compared to the single large anal plate of young Echini. Yet, while it may perhaps not be an embryonic feature of the Echini which runs back through the Echinoid series of the earlier palæozoic times, it may yet be one of those cases of the sudden reappearance of an ancient structual feature after a long period of time, as is also perhaps the five-valved actinal opening of Palæostoma. I am inclined to look upon the suranal plate of Salenia as strictly homologous with the central plate of the dorsal surface of Starfishes, which, while it recalls the Crinoidal affinities of the Echini, yet has not played the important part in the development of the Echinoid series which it did in the Starfishes or Crinoids.

As far as the plates of the anal system are concerned, the embryonic type of many plates arranged in more or less irregular concentric rows round the anal opening, such as we find it in the oldest palæozoic Echini, has remained remarkably persistent throughout the group to the present day. Even in the Spatangoids and Clypeastroids, in which the anal system has become disconnected from the apical system, the same general embryonic type has been retained in nearly all the principal groups, with the exception of a few types, such as Echinocidaris, and some of the Clypeastroids and Spatangoids, in which the number of anal plates has become reduced, and they form a pyramid over the anal system; a structural feature, however, which we should remember is already found in some of the earliest known Crinoids. From what I have shown of the mode of breaking up of the anal system* in some very large specimens of Arbacia, the pyramidal anal covering may have been the earliest type of plates of the anal system in Crinoids, and the splitting up of the plates of the anal system, at first few in number, may be a feature characteristic of the more recent Echini. Such a splitting up actually takes place in the growth of the plates of the anal system of Salenia. In very young stages of *S. Pattersoni* we have a suranal plate and five anal plates covering the anal system; while in old specimens the anal system is covered by a number of smaller plates, due to the splitting up in part of the original plates at their apex, and in part to the formation of new plates round the anal opening with the increase in size of the anal system.

How far we are justified in considering the anal plates of the recent Desmosticha as homologous with the dorso-central plate of young Starfishes and of Comatula, seems somewhat doubtful. P. H. Carpenter† has well discussed some of the difficulties to be met in adopting the view Lovén and myself have

* Challenger Echini, p. 56. † Quart. Journ. Mic. Soc., XVIII. 357.

taken of the homologies of the apical system of Echini and of the plates of the embryonic Comatula in its Pentacrinus stage. Neumayr's suggestion of the morphological value of the anal plates of the Palæchinidæ and Cidaridæ has thrown considerable light on this question, and shows us the possibility of a number of anal plates in Echini, say five for instance in Echinocidaris, being the homologue of the dorso-central plate of the Pentacrinus stage of Comatula. Of course we should remember that, in making this homology, we are comparing plates, which while they occupy the same structural position, have a very different physiological value. As I have already stated, we have the most positive proof of the origin of the dorso-central plate of Starfishes and Ophiurans as a single Y-shaped rod appearing simultaneously with the five basals; but we have no such definite data either for the Echini or for the Comatulæ while within the Pluteus. Such information would go far towards settling this disputed homology, for at present we are obliged to draw our conclusions from a comparison of the more advanced stages of development. The discovery of a pedunculated Starfish by the "Travailleur," the Caulaster of Perrier,* may throw important light on the homology of the centro-dorsal plate of the Starfishes and of the Crinoids.

The discovery by Laube in the Trias of the genus Tiarechinus of Neumayr shows that the pyramidal anal covering, composed of a few large plates, which appears in some of the earliest Crinoids known, has persisted or reappeared after a long lapse of time, during which the greater part of the Palæchini were provided with an anal system protected by one or two concentric rings of numerous plates; this last structural feature characterizing nearly all the modern Echini, only a few Clypeastroids and Spatangoids, and among the Desmosticha the Echinocidaridæ, still retaining the antique structure of the anal system, while in nearly all Echini from the oldest to those of the present day we may imagine the numerous anal plates to have been the result of the splitting up of the five (or more?) plates of the anal pyramids into numerous smaller plates. Where this splitting up took place regularly, we have the anal system of the Palæchinidæ, Cidaridæ, etc.; where, on the contrary, one plate resisted, we have what exists in Salenia and all the recent Echini, in which one of the anal plates has a great prominence over the others. The Salenia-like structure, therefore, may appear at any time, and disappear again, without perhaps having so important a morphological value as I was at first inclined to give it when I called attention to the

* *Comptes Rendus*, December 26, 1882.

existence of a large permanent anal plate in the young of many Echini among the Desmosticha.

I was in hopes that the examination of the series of young Saleniæ dredged by the "Blake" might throw some light on the formation of the suranal plate, and its homology with the single large anal plate of the early stages of young Echini belonging to other families. On examining these young Saleniæ I find that the abactinal system occupies a comparatively much greater space of the abactinal surface of the test than in the larger specimens. But in all the young stages, even when not measuring more than 1.5 mm. in diameter, the arrangement of the plates of the abactinal system does not differ from that of the older specimens, the suranal plate being only proportionally somewhat smaller. In the youngest Salenia collected (1.5 mm. in diameter) the sutures between the genital and ocular plates are, as in all young Echini, somewhat indistinct, and it is difficult to define the exact limits of the abactinal system. As I have already shown in other young Echini (Strongylocentrotus, Echinus, Arbacia, Diadema, etc.), the coronal plates of the test and the plates of the abactinal system are very indistinct in the stages immediately following the resorption of the Pluteus, while the actinal system is well defined. It is only later that the separation of the ambulacral and interambulacral areas can be traced; at about the same time the limits of the abactinal system become defined; and still later, the separation of that system into its component plates surrounding the anal system, which from the earliest stages is readily recognized. In the youngest stage of Salenia the anal system is distinctly pentagonal, and covered by eight large triangular plates with rounded tips; the plates carry small granules supporting minute sessile papillæ similar to those found on the genital and ocular plates, but smaller.

As in other young Echini, the anal system is comparatively large; the suranal plate is at first quite small, a narrow plate on the side of the anal system opposite to the nearest ocular plate. It appears to gain in size at the edges adjoining the genital plates. As fast as the plates of the genital ring increase, the pentagon they form round the suranal plate enlarges, and the outer edges of this plate keep pace in their growth with that of the inner edges of the adjoining genital plates. The genital and ocular plates carry three or four large granules irregularly placed on the plates, with a row of granules forming a line round the edge of the anal system. There are as yet no traces of the genital or ocular openings. The whole of the abactinal

ring is striated, the lines forming irregularly lozenge-shaped figures, arranged as they have been figured by Lovén for *Salenia goësiana* (Lovén, *Études sur les Échinoïdées*, Pl. XIX.). The limits of these figures, both in the smallest specimen and in one measuring 2 mm. in diameter, are somewhat indistinct, owing to the coarse, spongy granulation of the limestone tissue of the plates of the abactinal system. In the majority of the young specimens examined, this striation could not be detected at all, and in older specimens, measuring from 4–8 mm. in diameter, I was unable to do more than trace portions of this striation on account of the granulation of the plates.

I am now inclined to consider *Salenia goësiana* of Lovén as identical with *S. varispina;* it certainly agrees very closely with the young of *S. varispina* of the same size (3.5 mm.) collected by the "Blake" in the West Indies. These young specimens show, as I have stated above, the peculiar striation of the abactinal system of *S. goësiana*, though the size of the tubercles of the ambulacral system is somewhat smaller in the young of our *S. varispina* than in the figure given by Lovén. The abnormal position of the madreporic body in the original type specimen of *S. varispina* is also accounted for in the description which follows.

As regards the actinal system, in young specimens we find ten large plates in the continuation of the ambulacral system, spreading laterally so as to form a continuous ring. The space between the inner edge of these plates and the teeth is filled with small plates irregularly arranged. The ten large buccal tentacles are sometimes reduced to five, one in each ambulacrum being frequently atrophied or much smaller than the other. In these young specimens, the sphæridia first detected in this genus by Duncan* stand out very prominently between the first and second pair of ambulacral tentacles. I have only observed one in each ambulacral area in the smaller specimens; in older ones, we find sometimes as many as three at the base of the ambulacral area. The sphæridia of the younger Saleniæ are nearly hemispherical with a rather long peduncle; in older specimens, they become more ellipsoid, and are supported upon a comparatively shorter stem.

The primary spines of the youngest Saleniæ are very remarkable; the short, sharp spiny processes of the main shaft, which have been figured as characteristic of the primary spines of Saleniæ, are in these specimens replaced by long, slender, curved filiform processes, arranged on each side of the shaft, and equal in length three times the diameter of the shaft.

* Ann. and Mag. of Nat. Hist., XX. 70.

These delicate processes appear, however, to be soon either worn off or broken, as in specimens measuring from 2 to 3 mm. in diameter we generally find only an occasional primary spine still retaining the filiform processes, or a trace of them. As the spines become older, these processes are little by little changed to the sharp spiny processes figured as characteristic of *S. varispina*. The primary spines of these young stages are also marked for the single prominent verticillation formed near the base of the shaft by the somewhat stouter filaments of that portion of the radiole.

The young spines found on the small primary tubercles near the abactinal system on the ambulacral and interambulacral areas have a striking appearance. They recall somewhat the fan-shaped, short spiny radioles found on the test of very young specimens of Strongylocentrotus; they also recall the peculiar umbrella-shaped spines of Aceste, and of some deep-sea Ophiurans. The primary spines, when the shaft has as yet but a single pair of filaments, could readily pass for modified pedicellariæ; they also resemble the hook-like appendages of the Ophiurans. In the next stage the radioles carry from four to five processes, when the central part of the shaft begins to increase in length; with this increase commences also the formation of the filaments, so characteristic of the large primary interambulacral spines of the young stages. The primary interambulacral spines are usually similar, but shorter, slender-pointed radioles, with from six to eight processes and a ring of filaments near the base of the shaft. In the youngest stages there are as yet no papillæ; these appear only later, in larger specimens, and at first show no trace, in the interambulacral areas, of their regular Cidaris-like arrangement round the base of the primaries, as in the older stages. The papillæ when they first appear are short slender-pointed spines, with short, sharp processes, covered by lines of pigment-spots of dark violet. With the growth of the test these papillæ become club-shaped, curved, and finally flattened and fan-shaped, as they appear in the older Saleniæ. The papillæ of the anal plates are articulated in the older specimens; at first they are sessile, like the embryonic spines (club-shaped sessile papillæ) covering the plates of the genital ring; with the increasing size of the young Salenia they resemble more the coronal papillæ. These abactinal sessile papillæ are interesting, as they develop exactly as do the embryonic spines in young Echini, from the general granulation of the plates; but they remain, as in the Arbaciadæ, always sessile.

As I have stated, the genital openings are not yet formed in young speci-

mens, and in the older ones there seems to be considerable variation in the position of the madreporic body; so that the position of the madreporic genital can certainly not be taken as expressive of any generic value in this family, if we are to judge by the recent species. It is not uncommon (five specimens) to find two genital plates which carry traces of the madreporic body; and though the right genital is the one which is most commonly the madreporic, yet in the first specimen of this species of Salenia described it was the left genital plate which carried the madreporic body. This induced Duncan* to refer this species to Peltastes.†

The crenulation of the tubercles can be traced in the earliest stages examined, but its distinctness varies greatly in different individuals. It is quite distinct in the large primary tubercles near the abactinal region, it becomes indistinct near the ambitus, and at the actinostome the tubercles are smooth. The large primary pedicellariæ, both in the ambulacral and interambulacral areas, are not numerous. We do not find more than two large, short-stemmed, long-headed, slender-pronged pedicellariæ in each of these areas. The others, very numerous, are quite small, short-stemmed, stout-headed pedicellariæ. In the ambulacral system these small trifid pedicellariæ are thickly placed throughout the area; and in specimens measuring 7 or 8 mm. in diameter there are six or seven similar pedicellariæ in each of the large buccal plates of the actinostome.

The plates of the actinostome are more numerous than in *S. Pattersoni*, and are not as regularly arranged as in that species, in which the actinal imbricating plates resemble the actinal plates of the Cidaridæ, both in their regular arrangement and in forming the continuation of the ambulacral and interambulacral coronal plates on the actinal membrane. In a specimen of *S. varispina* measuring 7 mm. in diameter, there are four or five concentric rows of actinal plates between the large buccal plates and

* Ann. and Mag. of Nat. Hist., XX., 1877.

† This species is retained in the genus Salenia, although Dr. Duncan has proposed to remove it to Peltastes. As I have already stated in the Revision of the Echini, and in the Bulletin of the Museum (I., No. 9), when first describing this species, it differs somewhat from Salenia proper, but it does not seem to me to belong to the group of Salenidæ with which Peltastes is associated, in which the suranal plate is placed directly opposite one of the genital plates, while in all the recent Salenidæ thus far described they at least all agree in having an ocular plate opposed to the median line of the suranal plate, the adjoining genital plates uniting just in front of this imaginary median line so as to separate the ocular plate more or less from the anal system. (Vide A. Agassiz, Revision of the Echini; S. Lovén, *Echinoïdea*; M. P. Duncan, Ann. and Mag. of Nat. Hist., 1877, 1878; Wyv. Thomson, Voyage of the Challenger; A. Agassiz, Echinoidea of the Challenger.)

the actinal edge of the test. In a specimen of *S. Pattersoni*, measuring 14 mm. in diameter, we find only two or three rows. The granulation of the actinal plates is coarser in *S. varispina* than in *S. Pattersoni*.

The gills in specimens measuring 7–8 mm. in diameter are well developed as a short five-forked appendage covered by few pigment cells. In smaller specimens measuring 3 mm., the gills only fork once.

The more we examine the Saleniæ, the more we are inclined to consider the group as holding a position intermediate between the Cidaridæ and the Echinidæ. For while the general structure of the coronal plates of the actinal and abactinal system, of the spines, and of the papillæ, recalls the Cidaridæ, yet the structure of the teeth, the presence of gills with actinal cuts for their passage, and the existence of sphæridia, are all features which associate them with the Echinidæ proper.

Arbacia punctulata Gray.

Yucatan Bank. 14–84 fathoms.

Podocidaris sculpta A. Ag.

Off Morro Light. 250–400 fathoms.

It is not out of place while speaking of Podocidaris to call attention to the remarkable genus Tiarechinus of Neumayr,* one of the most characteristic embryonic genera I know. This diminutive Sea-urchin from the Trias of St. Cassian represents the young stages of Podocidaris at a time when neither the abactinal system nor the plates of the interambulacral area have become specialized. The whole abactinal part of the test appears from the figures of Neumayr to be still in the condition preceding the division of the abactinal system into an anal system and a genital ring, before the formation of the plates of the anal system or the division of the anal ring into its component parts. There are very faint indications of what I take to be the dividing lines between four genital plates in the figure of Neumayr. The actinal surface, on the contrary, is far more developed; the large primary tubercles of the interambulacral areas, and the structure of the ambulacral system, agree most strikingly with the condition of the actinal surface of young stages of Podocidaris and Arbacia. Compare the figures I have given in the Revision of the Echini, Plates IV., V., and Figs. 68, 69, p. 734.

* See the figure given in Plate II., Vol. LXXXIV. 1 Abth. p. 169, Sitzungsb. d. K. K. Akad. d. Wiss. Math. Nat. Cl., Wien, 1882.

* Podocidaris scutata A. Ag.

Podocidaris scutata A. Ag. Bull. M. C. Z., VIII., No. 2, p. 72, 1880.
Off Santa Cruz. 580 fathoms.

Only one specimen of this species was collected. It is much larger than either of the others of the genus. Test depressed, remarkable for its large abactinal system. The whole abactinal surface of test covered by small, distant, fine, slender fixed spines contrasting with the corresponding coarse granulation of *P. sculpta;* fewer large primary tubercles close to the ambitus on the actinal surface. Actinal membrane entirely covered by prominent imbricating plates; five anal plates, as in *P. prionigera*, to which it is most closely allied. Test light grayish brown when alive.

Cœlopleurus floridanus A. Ag.

Lat. 23° 52′ N., Long. 88° 5′ W. West India Islands, — Barbados. 56–1,323 fathoms; most abundant from 100–200 fathoms.
For other localities, see Bull. M. C. Z., V., No. 9, p. 188, 1878; VIII., No. 2, p. 73, 1880.

Pl. VII., Pl. VIII.

Many of the specimens of this species dredged in the Caribbean, off the Windward Islands, are much larger than the small specimens from which the species was first described. (Pl. VII. Fig. 1.; Pl. VIII. Figs. 1–6.) Quite a number of specimens measured 18 mm. in diameter and a few 28 mm. This species, however, does not seem to attain the size of the large *C. Maillardi.*

When alive it is most brilliantly colored, the test varying from a rich light chocolate in the interambulacra to the brilliant orange or yellow ambulacral areas. The primary radioles vary greatly in color, from a delicate straw, often nearly white, to a bright carmine or orange, the base of the spines being usually colored and the shaft more or less irregularly banded.

On Plate VIII. are given figures of specimens of different sizes, showing the changes they pass through due to growth. The larger specimens (Pl. VIII. Figs. 1–6), when compared with specimens of *C. Maillardi* of the same size, show that the Florida species differs from it in having a larger anal system, in the shape of the genital and ocular plates, which is quite different, being nearly triangular in the Florida species, in having a much wider bare interambulacral area, and comparatively larger primary ambulacral tubercles, concentrated nearer the ambitus; these tubercles do not extend to the genital ring, as they do with *C. Maillardi* in specimens of the same size.

The deep pits at the base of the median ambulacral area are larger and more numerous than in the Indian species. (Pl. VIII. Figs. 2, 3, 5.) The most striking features due to changes of growth are the comparatively late period at which the genital pores are developed, even specimens measuring 11 mm. in diameter (Pl. VIII. Figs. 7, 8) showing no trace of such openings. The genital plates of earlier stages are markedly pentagonal (Pl. VIII. Figs. 11, 12, 15, 18); the granulation of the anal edge of the genital plates is a character not found in the younger stages. In these young stages the primary tubercles extend also but little above the ambitus. (Pl. VIII. Figs. 7, 11, 15.) In Figure 15 the primary interambulacral tubercles are limited to the actinal surface, and the primary interambulacral tubercles extend at first but little towards the abactinal part of the ambulacral area. Compare Plate VIII. Figs. 7, 11, 15, and Plate VIII. Fig. 1, with their corresponding profile figures. The resemblance of these young stages of Cœlopleurus to some of the Cretaceous and Jurassic Echini, such as Tiarechinus, etc., is very striking.

The tendency to breaking up of the anal plates already noticed in some of the species of Arbaciadæ is shown in some of the younger stages by the ill-defined subdivision lines, such as are represented in Plate VIII. Figs. 15, 18.

The function of the ambulacral pits of this genus I have been unable to ascertain. The sutures present no trace whatever, in the specimens I have examined, of the remarkable dovetailing observed by Duncan in the pitted Temnopleuridæ.

Diadema setosum Gray.

Littoral to 115 fathoms. Florida and West India Islands.

ASPIDODIADEMA A. Ag.

A marked feature of this genus is the nearly uniform size of the secondary radioles, both in the ambulacral and interambulacral areas. This character is a structural feature which Aspidodiadema has in common with the Cidaridæ in addition to their similar abactinal system, to the structure of the ambulacral areas, etc.; features to which I have already called attention in the Preliminary Report of the Challenger Echini,* and in the final Report (p. 64).

I did not notice while examining the Challenger species of the genus

* Proc. Am. Acad., XIV. 199, 1879.

a remarkable and interesting type of pedicellariæ, which in *A. Jacobyi* are quite large and numerous, and are found scattered over the whole of the abactinal part of the test, especially in the ambulacral area. These are sheathed pedicellariæ, if I may call them so. The shaft consists of a long, slender radiole, distinctly articulated, surrounded by a huge fleshy sheath, swelling out into three large bags on the sides, covering a little more than half the length of the shaft. This sheath extends from the base, where it covers the articulation, to the extremity of the pedicellariæ, at the tip of which is placed a small head enclosed within this sheath. The sheath at the extremity expands into a three-lobed cupuliform tip. These pedicellariæ recall at once the remarkable sheathed secondary spines which I have described in *Asthenosoma Grubei*, they form an additional link in the chain, proving that pedicellariæ are only modified spines. The diminutive heads of these pedicellariæ, if completely resorbed, would leave us a sheathed spine identical with the sheathed spine of the Echinothuriæ; the existence in that family of club-shaped primary spines, as in *Phormosoma bursaria*, the tip of which is still sheathed to a certain extent, shows how close is the relation of the sheathed spines to true pedicellariæ.

How far this sheath is analogous to the peculiar gland discovered by Sladen* in some of the types of pedicellariæ, I am unable to state positively at present, but I am inclined to consider it as a modification of this gland. If this be so, the sheathed pedicellariæ are only an extreme modification of the simple extension of the muscular system of the test over the shaft of the spines, and over the stem of the ordinary type of pedicellariæ; this extension being either modified into a sheath covering the whole of the secondary or primary spines, or merely a part of the shaft; or into a gland; or into a sheath, such as we find it in Aspidodiadema and the Echinothuriæ.

* Aspidodiadema antillarum A. Ag.

Aspidodiadema antillarum A. Ag. Bull. M. C. Z., VIII., No. 2, p. 73, 1880.
Aspidodiadema microtuberculatum A. Ag. Bull. M. C. Z., V., No. 9, p. 188 (non Chall. Echinoidea).

Southeast extremity of Cuba, Santa Cruz to St. Vincent. 451 to 1,568 fathoms; most abundant between 400 and 800 fathoms.

Pl. IX.

The genital ring of *A. antillarum* is comparatively larger than that of *A. Jacobyi*. The plates of the genital and ocular system are of nearly uniform

* W. P. Sladen, Ann. and Mag. of Nat. Hist., August, 1880.

size; the former carry larger miliaries than the latter; the ocular plates are somewhat pentagonal, while the genital plates appear more rectangular with rounded corners.

The anal system is covered with minute irregularly arranged plates; those immediately surrounding the anal system are larger, and in older specimens soldered together to form an irregular calcareous ring round the opening. This ring carries larger miliaries than the other anal plates. The anal tube itself extends as a sort of proboscis beyond the general level of the anal system. It is strengthened by delicate longitudinal calcareous plates. In *A. tonsum* we find six plates nearly covering the anal system; in *A. microtuberculatum* there are a number of smaller plates arranged irregularly round the anal opening.

The actinal system is strengthened by ten large buccal plates, as in *A. microtuberculatum*, covering nearly the whole of the actinostome. The gills appear in the youngest specimen I have examined (3.5 mm. in diameter) as one-forked digits; they do not even in larger specimens take a great development, judging from alcoholic specimens.

We do not find in younger specimens any marked differences from the adult in the structure either of the actinal or of the abactinal system. The primary spines are proportionally larger and longer, but with the exception of the smaller number of coronal plates the differences due to growth do not seem to be important.

The sphæridia of this species when fully grown are large, globular, short-stemmed; they are placed mainly in the abactinal region of the test, but are also found near the actinostome and scattered over the whole length of the ambulacral system. Their number varies from two to four, and sometimes as many as six are found in each area.

The pedicellariæ are similar to those previously described as characteristic of the genus; they are either long narrow-headed and long-stemmed, or short-headed and stout-stemmed, or short-stemmed and pyramidally headed; the last are not numerous. The sheathed pedicellariæ are smaller and comparatively more slender than those of *A. Jacobyi*, the shaft is very slender, and the head quite diminutive; the sheathed pedicellariæ are most numerous in the ambulacral area above the ambitus near the abactinal region; those of the interambulacral areas are slightly larger and far less numerous.

In a specimen measuring 11 mm. in diameter, there are six interambulacral plates; in one measuring 7 mm. there are five. The secondaries and miliaries

are less numerous in this species than in *A. microtuberculatum*; it also differs from it in having three or four ambulacral plates (in the median region of the test) to each interambulacral plate, while there are no less than five or six in *A. microtuberculatum*. The proportions of the spines to the test and the general appearance recalls more *A. tonsum*, while the coloring when alive is more that of *A. microtuberculatum*, with a light violet or grayish pink test and the spines of the same tint but lighter. The primary spines are slender, as in *A. tonsum*, but they are more curved than in that species. The abactinal part of the test of *A. antillarum* is more flattened (Echinostrephus-like) than is the case in either of the species collected by the Challenger.

The largest specimens of this species collected did not measure more than 13 mm. in diameter.

In a specimen measuring 7.5 mm. in diameter, the anal system measured 3 mm., the abactinal 5 mm., and the actinal 3.75 mm. in diameter; the height of the test measured 3.75 mm.

In a specimen measuring 11 mm. in diameter, the anal system measured 3.6 mm., the abactinal 6.50 mm., and the actinal 5.50 mm. in diameter; the height of the test measured 6 mm.

* Aspidodiadema Jacobyi A. Ag.

Aspidodiadema Jacobyi A. Ag. Bull. M. C. Z., VIII., No. 2, p. 74, 1880.
Cayman Brac, Lesser Antilles. 95 to 297 fathoms.

Pl. IX^a.

The largest specimen of this species collected by the Blake measured 32 mm. in diameter. As in *A. microtuberculatum*, the primary spines are rather stout, curved, and comparatively short, they are somewhat more closely packed than in that species, from the greater number of primaries in the interambulacral areas, a specimen measuring 28 mm. in diameter having 11 : 12 primary tubercles. The miliaries are more distant than in that species, forming a belt of distinct irregularly arranged miliaries in the median interambulacral space. We find in this species, as in *A. tonsum*, large primary ambulacral tubercles, extending nearly to the abactinal system; all the largest tubercles being placed above the median line of the test, and gradually increasing in size from that point to the abactinal region, much as they do in Echinostrephus.

There are not more than three ambulacral plates to each interambulacral plate. The miliaries extend in horizontal lines between the pores, and form

a narrow irregular vertical line, separating the ambulacral from the interambulacral region. The primary spines of the two areas are similar, those of the ambulacral areas being smaller and more slender. The secondaries, though not numerous, are remarkable for their uniform size in both areas, and their arrangement recalls to a certain extent that of the papillæ of the Cidaridæ. In life the test is of a light greenish pink color, the areolas darker; the secondary spines are of a light pinkish tint, darker at the base; the primary radioles yellowish green, with a greenish chocolate base. In some specimens the test is also of this greenish chocolate color, the spines more whitish, or tending towards a dirty yellow.

The sheathed pedicellariæ are most numerous above the ambitus toward the abactinal region; the shaft of the pedicellariæ is nearly as long as that of the secondary spines; from their size the sheathed pedicellariæ are very prominent objects on the test.

The actinostome is covered by ten large buccal plates, as in *A. microtuberculatum* and *A. antillarum*, but these plates form a ring round the actinal opening, leaving a bare ring between them and the edge of the test.

There are eight large elliptical plates round the anal opening, somewhat as in *A. tonsum*, but having a larger ring covered by minute plates between them and the genital ring. The anal plates are closely tuberculated by miliaries nearly of the same size as the miliaries of the ocular plates; the genital plates are coarsely and closely tuberculated by miliaries.

Smaller specimens differ from the larger ones mainly in the lighter coloring of the test and spines, and the more flattened abactinal region of the test, which loses its peculiar Echinostrephus-like shape as it increases in size, becoming more regularly arched, as in Amblypneustes. The plates of the actinal and anal system cover a comparatively larger space in younger specimens.

In a small specimen measuring about 3 mm., the anal plates appear as forming close to the genital ring; the difference in size of the genital and ocular plates is already apparent. The anal proboscis is quite long at that stage, equalling in length the diameter of the anal system.

In a specimen measuring 28 mm. in diameter, the anal system measured 5.50 mm., the abactinal 10 mm., and the actinal 9 mm.; the height of the test was 20 mm.; and there were eleven and twelve plates in the interambulacral areas.

In a specimen measuring 12 mm. in diameter, the anal system measured

3.25 mm., the abactinal 5.50 mm., and the actinal 5 mm.; the height of the test was 9 mm.; with nine and ten plates in the interambulacral areas.

In a specimen measuring 5 mm. in diameter, the anal system measured 1.25 mm., the abactinal 3 mm., and the actinal 2 mm.; with seven and eight plates in the interambulacral areas.

Asthenosoma hystrix A. Ag.

Asthenosoma Reynoldsii A. Ag. Bull. M. C. Z., VIII., No. 2, p. 75, 1880.
Montserrat, Santa Cruz, Barbados. 103–373 fathoms.

Pl. XIII., Pl. XIV.

The differences which I noticed (Preliminary Report on the Blake Echini, Bull. M. C. Z., VIII., No. 2, p. 75) in some of the larger specimens of Asthenosoma collected by the Blake, seemed to be of sufficient importance to separate them from *A. hystrix* under the name of *A. Reynoldsii*. A more careful examination of the large series of Asthenosoma collected by the Blake has satisfied me that the differences, striking as they appear at first sight, are merely due to age, and that what I had called *A. Reynoldsii* in the Preliminary Report are only large specimens of *A. hystrix*. Specimens measuring about 125 mm. in diameter are figured by Thomson in the Porcupine Echini, Pls. LXIV., LXV.; and by me in Pl. II. of the Hassler Echini (70 mm. in diameter). I have figured on Pls. XIII. and XIV. two specimens 165 mm. in diameter, showing the features characteristic of the largest *A. Reynoldsii* collected, which measured about 170 mm. in diameter.

In the smaller specimens, less than 70 mm. in diameter, the coronal plates of both areas are relatively narrower than in larger specimens, and while the general arrangement of the primary tubercles does not differ greatly in specimens of different sizes between 50 and 120 mm. in diameter, in the ambulacral areas, or in the two areas above the ambitus, yet there are very considerable differences to be noticed in the interambulacral areas on the actinal side. We find in larger specimens a third, and sometimes even a fourth, vertical row of primary tubercles extending from near the actinostome to above the ambitus. Compare Pl. XIV. Fig. 4, with the figures of Thomson in the Porcupine Echini, and those of the Hassler Echini quoted above.

The smaller specimens less than 70 mm. in diameter are usually of a brilliant claret-color, but often of a light pink color with only darker patches of deep claret on the actinal side; we find larger specimens

usually of a paler color tending to pinkish brown, with dark claret patches on the actinal side; these patches often disappear completely, and the test is then of an ashy light-brownish pink, with spines of a lighter color and of a greenish tint.

The sharp, small secondary spines which cover the test, as has already been noticed by Thomson and Moseley, cause very severe pain to the hands and arms if these urchins are handled carelessly, and nothing can be more disagreeable than the sharp pain which shoots up one's arm on rashly taking hold of these prizes as they are first brought up by the trawl. The after effects resemble those produced by nettles; the disagreeable feeling often does not disappear for twenty-four hours.

Phormosoma placenta Wyv. Thoms.

Phormosoma Sigsbei A. Ag. Bull. M. C. Z., VIII., No. 2, p. 75, 1880.
Lesser Antilles, — Lat. 41° 29′ 45″ N., Long. 65° 47′ 10″ W. 154–1242 fathoms.

Pl. XII., Pl. XV. Figs. 3–19.

To the leeward of the Lesser Antilles this species is found between 150 and 400 fathoms. On the east coast, in the Atlantic, it has been dredged from 810 to 1242 fathoms.

I owe to Mr. Murray the opportunity of examining an excellent series of specimens of *P. placenta* collected by the "Knight-Errant" in the Faroe Channel. The single specimen collected by Thomson in the "Porcupine," and from which his description was made,* was quite imperfect, and I was misled in describing this species again under the name of *P. Sigsbei* from specimens collected by the "Blake" in the Caribbean and off the east coast of the United States as far north as Lat. 41° 30′ N. This species has also been collected by the U. S. Fish Commission off Martha's Vineyard.

In the younger stages of this species we find great differences in the thickness of the test, and the relative size of the abactinal and actinal systems as compared with the diameter of the test. We find the same sort of differences, so marked in Toxopneustes from different localities, as regards the permanence of the primary tuberculation and the number of principal vertical rows. The tuberculation of the actinal surface does not differ greatly in specimens of different size; but in some specimens the tuberculation of the abactinal surface may be limited to a couple of principal vertical

* Transactions of the Royal Society, Vol. CLXIV. Pt. 2, p. 732, Pls. LXII., LXIII.

rows along the outer edge of the interambulacral plates, or the plates in specimens of the same size may carry the same vertical rows nearly to the apical system, but placed in the central part.

This arrangement, together with the greater thickness of the test, gives to these specimens a very different facies, closely resembling in the arrangement of the tubercles *P. rigida* and other small Echinothuriæ, which, when writing the Report on the Echini of the Challenger, I could not refer to any of the species collected by that expedition.

The color of the specimens with a thick test is of a deep claret, while usually the majority of the specimens of *P. placenta* with a thinner test are of a brick color, or of a yellowish orange, darker on the actinal side, and near the ambitus on the abactinal side, and becoming quite light-colored, either pinkish or yellowish, towards the apical system.

In the youngest specimen of Phormosoma collected by the Blake, measuring 8 mm. in diameter, the plates of the actinal system have already assumed the characteristic arrangement of the adult, although there are as yet but three rows of imbricating plates. We do not find in this species, as in two of the species of the Challenger collection (*P. tenuis* and *P. uranus?* Challenger Echini, Pl. XVIII[c]. Figs. 7, 12), that the buccal tentacular plates differ in size from those following them, recalling the general arrangement of the buccal plates of young Echinidæ proper. On the contrary, although the Blake specimens were no larger than the corresponding stages of the Challenger species, they show that in this species of Phormosoma the characteristic structural features of the Echinothuriæ are already developed. This, as I have already shown, we also find to be the case in young Cidaridæ. It thus appears that in some of the species of Echinothuriæ the Echinid features of the actinostome seem to be retained much longer than in others, and do not even seem always to be developed, if we may judge from the young stages of the West Indian Phormosoma here described.

The mode of formation of the coronal plates, and of the actinal and abactinal systems, is well shown in the series of the young of Phormosoma I have had occasion to examine. As I have suggested before, the Echinothuriæ are the most embryonic of the Echini. The coronal plates when they first appear, somewhat indistinctly defined, in young specimens measuring about 8 mm. in diameter, show very clearly that there is no special line of demarkation to be drawn in the young stages between the abactinal and

coronal system. From seven to nine of the coronal plates appear at the same time, the division line of the sutures being traced with difficulty in young specimens measuring 8 mm. in diameter, but becoming well defined in somewhat larger specimens of from 17 to 20 mm. in diameter.

In the youngest stage (8 mm. in diameter) the actinal plates are separated from the coronal plates, and are developed, as I have shown, in the same manner as the imbricating plates of the Cidaridæ, independently of the coronal plates; new plates forming on the distal surface of the actinostome, which are intercalated between the old plates and the coronal plates. On the abactinal system, on the contrary, while the plates of the genital ring are well defined and seem to be distinctly separated from the coronal plates, yet new interambulacral plates are not added independently, as in the ambulacral system, and as in the interambulacral system of other young Echinoids where the genital ring remains permanently closed. The new interambulacral plates are found to be pushing out from the plates of the anal system on each side of the genital plates. As the ocular and genital plates of the genital ring become separated, with increasing size, the additional anal plates formed in the intervening spaces are pushed out, and become a part of the abactinal portion of the interambulacral area.

This mode of growth of the interambulacral areas combines to a certain extent the modes of formation of the plates of the abactinal system of young Starfishes and of young Ophiurans, in which the interambulacral plates are derived directly from the plates of the abactinal system. This shows a far closer relationship between the young of some of the Sea-urchins of the present day with Starfishes and Ophiurans on the one side, and Holothurians on the other, than had been suspected formerly. The plates are formed by a close-meshed reticulation of small, comparatively thick Y-shaped rods, with bare interstices for the joints of the plates. The tubercles of the miliaries and of the pedicellariæ are built up by a close accumulation of these meshes, forming what appears a fine granulation. The small tubercles are formed by the clustering together of five or six larger cells, arranged concentrically round a central space, which eventually forms the perforation of the tubercle; as this increases in size, the mammary boss is gradually formed from a similar concentration of the limestone meshes, and finally the edge of the boss becomes indistinctly crenulated. The tubercles, when arrested in their development in any one of these successive stages, form what are known as miliary, as secondary small primary, and as primary tubercles.

The characteristic pedicellariæ of the genus appear early. A few pedicellariæ of the different kinds noticed in the adult of this species are found in young specimens scattered over the test, mainly on the actinal surface. Sphæridia are also present in these youngest stages; they are found extending from the plates of the actinal membrane, close to the teeth, to the abactinal area, along a line at the base of the ambulacral tentacles, usually one for each tentacle; in older stages they are rarely seen, being probably broken off. If the Cidaridæ possess sphæridia, we may perhaps look for them, in the young stages, on the imbricating plates of the actinal membrane.

In the early stages of growth the plates of the genital ring are in contact along their edges; as the young become older, the space between the ocular and genital plates increases, and they become separated by a number of anal plates. The anal system is at first, in the youngest specimens, covered by plates of a nearly uniform size, with only a few smaller ones occasionally intercalated between them; with increasing size the number of these intercalated plates becomes larger, and the original larger anal plates are then separated by a greater number of accessory ones. The large original plates retain their prominence in later stages of growth, and, much as the single embryonic anal plate of young Echinoids, can easily be traced, in older stages, among the other anal plates of subsequent growth.

I do not quite understand Neumayr's statement that in the young Glyphostomes the anal plate is first formed, and that the plates of the genital ring are formed later and become detached from it laterally. That certainly is not the case in any of the young Echini I have had occasion to examine. While undoubtedly the anal plate is the first plate to appear, yet the genital and ocular plates are formed outside and independently of it, just as much as in the young stages of Comatula the basalia arise independently of the dorso-central plate, and just as independently as the same plates arise independently in the young Starfishes. See my Embryology of the Starfishes, and Lovén's figures.

As I have previously shown in speaking of the apical system of the Palæchinidæ and Echinothuriæ, the plates of the apex of the anal system hold a very different relation to the interambulacral system in those groups from what they do in the Echinidæ, in which the genital ring is closed, a condition of things which begins only with the Echini of Mesozoic times, and is represented in the Cidaridæ by their having still a number of plates,

no one of which becomes more prominent than the others. This is the case only in the Saleniæ and in the young stages of Echinidæ, and does not seem to have reached as yet its greatest development in the Echini of the present period. Unfortunately there is no Pluteus of Echinus figured in a stage showing the first appearance of the calcareous rods. Such an observation might throw very important light on the homology of the Echinoid apical system.

The apical system of two specimens of *Asthenosoma varium*, figured by Ludwig,* is interesting, as it is the only species of Echinothuria in which the genital ring is closed, connecting the structure of the apical system with that of the Diadematidæ proper. It is true that the specimens of which Ludwig figures the abactinal system were not fully grown, and were much smaller than the specimens of the allied species *A. Grubei*, figured in the Echini of the Challenger Report, Plates XV.–XVII., in which the genital ring is less open than in any other species of Asthenosoma I have had occasion to examine. It will be seen, on examining the figures of young Echinothuriæ in the Report on the Echini of the Challenger, that, while the plates of the genital ring are placed nearer together in the young stages than in older specimens, yet they are more or less separated even in the earlier stages by the anal plates, which force their way between the ocular plates and the two sides of the genital plates in the two zones of the apical part of the inter-ambulacral area.

In the early stages (8 mm. in diameter), the ambulacral tentacles are arranged in a single vertical row, extending from the actinal opening to the ocular plate. It is only in specimens measuring from 28 to 40 mm. in diameter that we can find the characteristic generic arrangement of the ambulacral tubes. In specimens measuring from 17 to 25 mm. in diameter, the actinal imbricating plates have increased to four, the gills are well developed, and the final arrangement of the primary tubercles both of the actinal and abactinal surface is indicated in a general way on the plates adjoining the ambitus, in both the ambulacral and interambulacral areas. The marginal fasciole can already be made out in specimens measuring about 28 mm. in diameter; in specimens of 50 mm. in diameter it is quite prominent.

The lapping of the coronal plates takes place at a later stage of growth than that of the plates of the actinal membrane; the latter are distinctly

* Zeitsch. f. Wiss. Zool., XXXIV., Pl. II.

imbricated towards the actinal opening from their first appearance. It is only when the young Phormosoma has attained a diameter of from 35 to 45 mm. that the lapping of the coronal plates of the ambulacral and interambulacral areas becomes distinct.

As in the young of other Echini the genital and ocular plates are not perforated in the youngest stages, nor can the madreporic genital be distinguished from the others, owing to the similarity of the calcareous meshes of the young genital plates to the openings of the madreporic canal. In somewhat older stages, however, the madreporic genital is readily distinguished from the others (in a specimen measuring 20 mm. in diameter). This is also the stage at which the other plates of the abactinal system begin to show the perforations for the genital and ocular pores.

It is interesting to compare the structure of a young Astropyga (Pl. XV. Figs. 1, 2), measuring 13 mm. in diameter, with these young stages of Phormosoma (Pl. XV. Figs. 3–19). This comparison clearly brings out the striking difference between the structure of the actinal and abactinal systems in the Diadematidæ and Echinothuriæ. In Astropyga the genital ring always remains closed, and the actinal system is provided with the ten large buccal plates characteristic of young Echinidæ, and with an irregular imbricating system of small imperforated plates forming a regular ambulacral and an irregular interambulacral series. The peculiar forked band of pigment cells of the abactinal part of the coronal plates so characteristic of Astropyga seems to be the remnant of the pigment spots which are irregularly scattered over the test of young Echinothuriæ, and which in the Diadematidæ have a regular arrangement. These large pigment spots are eminently an embryonic character, for we find the test of the young stages of regular Echini thickly covered with large prominent patches of pigment.

Phormosoma uranus Wyv. Thoms.

Phormosoma Petersii A. Ag. Bull. M. C. Z., VIII., No. 2, p. 76, 1880.
Lesser Antilles,—Lat. 39° 45′ 40″ N., Long. 70° 55′ W. 399–1221 fathoms.

Pl. X., Pl. XI.

Thomson figured in the "Voyage of the Challenger" (I., p. 146, Fig. 33, p. 147, Fig. 34) a small specimen of Phormosoma which he called *P. uranus*. It differed very strikingly from specimens of a closely allied species collected by the Blake, which I had provisionally named *P. Petersii*. The principal

structural feature of *P. uranus* consists in the extreme tenuity of the test, and in the fact that "there is but little difference in character between the upper and lower surfaces of the test, and the species thus holds a place intermediate between the genera Phormosoma and Calveria." While this is true of specimens of the size of that figured by Thomson, and of younger ones, it does not hold good for larger specimens, in which we find that the larger tubercles of the actinal surface are comparatively small, and not limited to a narrow band of the actinal and abactinal surfaces immediately adjoining the ambitus. But, on the contrary, in older and larger specimens the primary tubercles of the actinal surface become larger with age, extending at the same time over a greater portion of the actinal surface from the ambitus towards the actinostome, as in other species of the genus Phormosoma. Of *P. uranus* I had on former occasions only the opportunity of examining the very imperfect specimen described by Thomson. Since that time Mr. Murray has sent me for examination the Echini collected by the Knight-Errant in the Faroe Channel. Among them was a specimen of *P. uranus* intermediate in size between the smaller specimen described by Thomson and the larger and older specimens collected by the Blake from the West Indies and off the southern part of the Atlantic coast of the United States, which I had named *P. Petersii*. A renewed comparison of the specimens with this additional material plainly shows that the differences which had been noticed between them were merely due to age, and that in this species the great development of the large primary tubercles of the actinal surface takes place at a late period of growth. The abactinal system also seems to increase more rapidly in size in proportion to the rest of the test, as the specimens grow larger; so that in younger specimens the abactinal system is relatively smaller compared with the diameter of the test than in the larger ones. The specimens collected were all of a brilliant claret-color.

Echinometra subangularis Desml.

Florida, West India Islands. Littoral to 250 fathoms.

Strongylocentrotus Drobachiensis A. Ag.

(East Coast of United States,) Lat. 41° 30′ N., Long. 66° W., in 73 fathoms.

TEMNOPLEURIDÆ.

Duncan* has, in interesting articles on the pits and sutures of Temnopleurus and on the structure of Pleurechinus, called attention to the important differences existing between the Temnopleuridæ of the type of Temnopleurus proper and its allies, and such genera as Temnechinus and Trigonocidaris, which have been associated with them.

He proposes to place on one side the genera Pleurechinus, Temnopleurus, Salmacis, and Amblypneustes, which have true pits, and on the other side the genera Temnechinus, Trigonocidaris, Paradoxechinus, and Glyphocyphus, which have raised ribs.

The structural difference so well pointed out by Duncan is an important one; he says he was unable to find, in the specimens of Temnechinus from the Crag which he examined, any trace of the remarkable "deep inward undermining or penetrations of the test" of Temnopleurus. The specimens of *Temnechinus maculatus* of different sizes which I have examined show no trace of pits, nor of this system of dowelling at the junction of the plates. I have also again examined specimens of the recent *Trigonocidaris albida*, and do not find in that species either the sunken pits of Temnopleurus proper or the dowelling.

Duncan and Sladen† have figured in the fossils of Western Sind two other genera closely allied to Trigonocidaris: Dictyopleurus and Arachnopleurus, in which the grooved and pitted ornamentation of the test is produced entirely by ribs and elevations. The peculiar structure of the ornamentation of the genus Progonechinus shows how difficult it may become to maintain the distinction suggested by Duncan.

I had already called attention in the Revision of the Echini, p. 286, to the character of the ornamentation of the test of some of the Temnopleuridæ, and to its probable derivation from a more simple type of ribbed ornamentation, such as is formed by the radiating arrangement of miliaries and secondaries round the primary tubercle of some of the Triplechinidæ and

* P. M. Duncan, On some Points in the Morphology of the Test of Temnopleuridæ, Journal Linn. Soc. London, 1882, Vol. XVI. p. 343. On the Genus Pleurechinus, L. Agassiz, Journal Linn. Soc. London, 1882, Vol. XVI. p. 417.

† Mem. Geol. Survey of India, Ser. XIV., Vol. I., The Fossil Echinoidea, Fasicul. II. Calcutta, 1882.

Arbaciadæ. The next stage being the formation of low radiating spokes round the primaries formed by the running together of flattened miliaries or secondaries. From this type of ornamentation the passage is an easy one to the marked and prominent ridges of Trigonocidaris, Dictyopleurus, and the like. But, as I have shown when speaking of the changes due to growth in young Temnopleuridæ, the presence of pits and sutures is a feature only developed with age, and the transition is insensible between the types in which the pits and sutures are formed by the modification of a flat surface due on one side to the thickening or elevation of nearly the whole plate, or, on the other, of only a portion of it. This still leaves, however, as characteristic of the Temnopleuridæ and their nearest allies as limited by Duncan, the remarkable dowelling of the sutural faces.

The peculiar sunken pits of the Clypeastroids extending around the primary tubercles reach deep into the thickness of the test; they are not to be regarded as merely sunken areolas. In some of the Nucleolidæ we have a similar sunken area round the primaries; on the actinal side, round the actinostome of such genera as Rhynchopygus, these pits are independent of the tuberculation, and form very deeply sunken and irregularly shaped grooves in the thickness of the test. In Goniocidaris, another genus in which we have pits and sutural bands, they are not deep, and do not extend into the thickness of the test.

Temnechinus maculatus A. Ag.

Lat. 26° 31′ N., Long. 85° 53′ W. Lesser Antilles, Florida. 73–229 fathoms.
For list of Stations, see Bull. M. C. Z., V., No. 9, p. 189, 1878; VIII., No. 2, p. 76, 1880.

This species has also been dredged by the U. S. Fish Commission off Newport in deep water.

Trigonocidaris albida A. Ag.

Lat. 24° 15′ N., Long. 82° 13′ W. Florida, Lesser Antilles. 124–150 fathoms.
For list of Stations, see Bull. M. C. Z., V., No. 9, p. 189, 1878; VIII., No. 2, p. 77, 1880.

Echinus gracilis A. Ag.

Straits of Florida, West Indies, East Coast of U. S., and as far north as off Martha's Vineyard, by the U. S. Fish Commission. 93–200 fathoms.

Echinus norvegicus Düb. o. Kor.

Off Newport, in Lat. 39° to 41° N. Very common in 1242 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 77, 1880.

It seems almost hopeless to attempt to distinguish the species of Echinus known as *E. elegans*, *E. norvegicus*, *E. melo*, and *E. Flemingii*. While the specimens from the same localities usually vary but little, those of adjoining or distant localities vary to such an extent that they generally combine more or less the specific features by which we have become accustomed to separate the above-named species.

A large series of *E. norvegicus* from 1242 fathoms shows but the slightest possible variation among the different individuals; yet they all have the anal system which thus far has been considered characteristic of *E. elegans*.

The largest specimens I have seen of this species were collected by the "Porcupine," but they differ in no marked way from the typical *E. norvegicus*.

* Echinus Wallisi A. Ag.

Echinus Wallisi A. Ag. Bull. M. C. Z., VIII., No. 2, p. 77, 1880.
Atlantic Coast of U. S., Lat. 31°–41° N., Long. 65°–74° W. 257–1047 fathoms.

This species is evidently closely allied to, if not identical with, *Echinus Alexandri*, subsequently described (1882) by Danielssen and Koren. They have given a very characteristic and excellent figure of this species in Plates III. and IV., Figs. 7–16, of Nyt. Mag. for Naturvid., XXXVII. For their description, see page 294 of the same article. *E. Alexandri* was dredged from a depth of 536 fathoms, Lat. 69° 18′ N., Long. 14° 32′.7 E.

This is a large species allied to *E. Flemingii* and *E. elegans*. The test is somewhat depressed. It is readily distinguished by the close secondary tuberculation surrounding the primary tubercles, and by the arrangement of the pairs of pores in sets of two. The primary spines are long and sharp, like those of *E. Flemingii*. The anal system is intermediate in size between that of *E. Flemingii* and that of *E. elegans*. When alive it was of a brilliant dark reddish pink color, the test of a darker shade than the spines; these are darkest at the base and pinkish at the tip. The smallest specimen collected measured about half an inch in diameter. A fine large specimen of this species, measuring three and a half inches in diameter, was collected. It has also been found off Newport by the U. S. Fish Commission.

Toxopneustes variegatus A. Ag.

Yucatan Bank, Florida, Lesser Antilles. Lat. 32° 25′ N., Long. 77° 42′ 30″ W. 14–300 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 78, 1880.

Hipponoë esculenta A. Ag.

Yucatan Bank, Cuba, Florida, Lesser Antilles. 14–451 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 78, 1880.

Echinocyamus pusillus Van Ph.

Florida Bank, Florida, Cuba, Lesser Antilles. 98–805 fathoms; most abundant between 150 and 400 fathoms.
For list of Stations, see Bull. M. C. Z., V., No. 9, p. 189, 1878; VIII., No. 2, p. 78, 1880.

An immense number of dead tests of this species were dredged in the Caribbean, the Gulf of Mexico, and the Straits of Florida. It has not yet been found to the northward of the Straits of Bemini. The number of living specimens brought up is small. It is interesting to note, in this connection, that the dead tests of species of Clypeaster, of Echinanthus, of Encope, of Schizaster, of Macropneustes, of Agassizia, of Echinolampas, of Linopneustes, of Toxopneustes, of Trigonocidaris, of Temnechinus, of Salenia, and of Cidaris, were also frequently dredged, and sometimes in considerable numbers. This has an important bearing as indicating the species which are likely hereafter to be preserved as fossils, and shows us how difficult it may become, even when we have such an abundant and characteristic Echinid fauna as that of the West Indies, to reconstruct it from the future fossils. It is also interesting to note that the genera (except Echinocyamus) of which we so frequently find the dead tests are the same which have been known as characteristic of the West Indies since the earliest tertiary. Evidently, except under the most favorable circumstances, we cannot expect to find represented as fossils the Echinothuriæ, Pourtalesiæ, and many of the Echinidæ, which after death readily fall to pieces, and may be dissolved by the excess of carbonic acid at great depth before they become protected by a covering of deep-sea ooze.

Clypeaster latissimus A. Ag.

Laganum latissimum Hupé, 1856, Castel Voy. Am. Sud., p. 98 (non Lam.).

Yucatan Bank, Lesser Antilles. Santa Cruz, 218 fathoms; Dominica, 98 fathoms; Montserrat, 88 fathoms; Lat. 18° 12′ N., Long. 61°, 1952 fathoms; Granada, 92 fathoms.

Pl. XV[b]. Figs. 3, 4; Pl. XV[c]. Figs. 3, 4.

The Blake dredged a number of specimens of the flat Clypeastroids. With this additional material I have made a renewed comparison of the species I had been led to unite under the name of *Clypeaster subdepressus* in the Revision of the Echini. I am now inclined to recognize three West Indian species of the genus Clypeaster, all of which had been before described on what I presumed to be insufficient data, and from the great variations I had observed in the shallow-water *C. subdepressus* of Florida I was induced, at the time of writing the Revision, to consider these so-called species as all belonging to the common Florida species. The remarkable constancy of certain characters, however, in the series I have collected, has led me to return to the old specific distinctions, and to recognize three well-marked specific types in the genus.

The typical *Clypeaster subdepressus*, with a large rosette, a thick rounded edge, and the test but slightly arched in the petaloid region, and with close, remarkably uniform tuberculation extending over the whole of the actinal surface of the test, close to the ambulacral furrows, which disappear in the tuberculation near the edge of the test. On the abactinal side the whole surface is covered by a close tuberculation, smaller than that of the oral surface, and the tubercles are separated by a fine granulation.

The second species, *C. latissimus*, is marked for its thin test, and for its small ambulacral rosette, which does not extend more than half-way from the apex to the edge of the test; the whole abactinal surface is covered by a close pavement of minute miliary granulation, with the exception of a small part of both the ambulacral and interambulacral areas adjoining the apex, where we find a few large distant primary tubercles. On the actinal side the tuberculation is very striking; primary tubercles similar to those of the apex extend around the edge of the test, as they pass towards the actinostome diminishing rapidly in size on the ambulacra towards the median part of the furrow, which is covered by fine miliary granulations. Along the edge of the furrow there are small primaries passing into larger primary

tubercles with three or four still larger primaries towards the outer edges of the ambulacral plates. The interambulacral plates carry huge primary tubercles, three or four to each plate, arranged in irregular concentric rows. These tubercles increase in size towards the central part of the interambulacral area, and then diminish again in size towards the actinostome. The intertubercular space is closely packed by a minute miliary granulation. The miliary granules of the actinal and abactinal surface carry short, sharp, straight miliary spines; these are somewhat larger, and curved on the edges of the furrows and over the petaloid ambulacra. The large primary spines of the interambulacral areas of the actinal side are long, stout, curved, slightly spathiform, and recall somewhat for Clypeastroids the Lovenia type of spines and of tuberculation.

The color of these flat Laganum-like specimens is bright yellowish green when alive; the large spines are of a lighter yellow color. This species is undoubtedly the one Hupé referred to *Laganum latissimum*.

The third type, which I have figured on Plate XI[c]. of the Revision, and described under the name of *Stolonoclypus Ravenellii*, is characterized by the thick-swollen edge and the high central part of the test, by the large open petals with the distant pairs of pores, succeeding pairs being about twice as far apart as in *C. subdepressus* and *C. latissimus*, and by its distant uniform primary and coarse intertubercular granulation. As in *C. subdepressus*, the granulation covers the abactinal surface uniformly. On the actinal side it is coarser, more distant, the tuberculation becoming smaller as it passes into the ambulacral areas, leaving the greater part of the ambulacral plates merely covered by a fine miliary granulation.

The figures I have given in the Revision of the Echini as characteristic of the young stages of *Clypeaster subdepressus* are on Plate XIII. Figs. 10–18; these, however, all belong to the swollen-edge type, *C. Ravenellii;* the other, Plate XII[a]. Fig. 4, is a young of *C. latissimus*. An excellent series of the young stages of *C. latissimus* shows that in these very flat Clypeastroids the needle-like or separate lamellar pillars forming the inner partitions become united together at their extremity, either simply at the base or along the whole height of the pillar, so as to form more or less irregular concentric and dendritic partitions or isolated pillars arranged in concentric rows.

The structure of the partitions in *C. latissimus*, and the presence of ambulacral furrows, show a close relationship between the flat Clypeastroids and the

Laganidæ.* Among the specimens I have had occasion to examine I do not find any marked difference due to age in the width of the marginal edge which is occupied by the pillars. The structure of the test of the flat Clypeastroids shows that they are closely connected with Conoclypus, the ambulacral furrows and the teeth specially showing these groups to have an intimate connection. Echinolampas, on the contrary, although superficially more closely related, in reality differs more from Conoclypus than do the flat Clypeastroids.

Clypeaster Ravenellii A. Ag.

Stolonoclypus Ravenellii A. Ag. Bull. M. C. Z., I. p. 265, 1869.
West Florida Bank. 14 fathoms. Yucatan Bank. 84 fathoms.

Pl. XV^b. Figs. 1, 2; Pl. XV^c. Figs. 1, 2.

Clypeaster subdepressus Agass.

Florida, Yucatan Bank, Lesser Antilles. 84–1952 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 79, 1880.

Pl. XV^a.

Echinanthus rosaceus Gray.

Yucatan, Cuba, Lesser Antilles. 14–118 fathoms.

The specimens dredged by the Blake show the usual differences in the comparative height and length of the test.

Echinarachnius parma Gray.

Lat. 40° 59′ N., Long. 71° 22′ 30″ W. Lat. 41° 30′ N., Long. 66° W. Off Newport. 71–306 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 79, 1880.

The genus Echinarachnius extends to a greater depth than Mellita. The former was very common beyond the 100 fathom line north of New York, and on the George's Bank, but to the south it was not found at the same depth, nor were any of the species of Mellita, and but one of Encope, dredged by the Blake beyond the 100 fathom line in the very districts in which these genera are the most typical littoral species.

* I would refer also to an article on the Laganidæ in Ann. and Mag. Nat. Hist., No. 62, for February, 1883. I do not propose to discuss the statements made by Prof. F. J. Bell.

Encope Michelini Agass.

Yucatan Bank. 14 fathoms.

Echinonëus semilunaris Lamk.

Cuba. Littoral to 80 fathoms.

Neolampas rostellata A. Ag.

Florida Bank. 229 fathoms.

Pl. XXII.

A number of specimens of this interesting genus, of all stages of growth, having been collected by the Blake in the Straits of Florida, I am able to add considerably to our previous knowledge of the genus. As in all Cassiduloids, the affinities of the family to the Clypeastroids is more or less marked. In the young specimens from Florida the changes taking place in the actinostome, in the ambulacral system, and in the shape of the test, as well as the structure of the pedicellariæ and of the abactinal system, all show strikingly the close affinities of the family with the Clypeastroids.

In the youngest stage examined, measuring only 2.5 mm. in length, the test, instead of being globular, as is the case in the Spatangoids proper, is quite flattened, its outline is elliptical, the anal system is covered by few large plates, and the general aspect of the young Neolampas at this stage and in the following one, when it measures about 4.5 mm. in length, closely resembles the young of some of the true Clypeastroids which I have had occasion to examine, such as Echinocyamus, Mellita, or Echinarachnius.

On their first appearance the bourrelets and phyllodes are with difficulty made out, and in the earliest stages the actinostome shows no trace whatever of them. The ambulacral suckers are, like those of the Clypeastroids, provided with powerful suckers near the actinostome, which are but slightly developed above the ambitus; we find no fimbriated actinal tentacles, even in the largest specimens collected, measuring 12 mm. in length, so characteristic of the Spatangoids proper. The bourrelets are well developed in specimens of 10 mm. in length, and in the largest specimen (12 mm. long) they have become very prominent. The lateral crowding of the ambulacral plates near the actinostome to form the phyllodes is well shown on comparing the arrangement and size of the plates as seen from the interior of the test

in two specimens, one of which measured probably 7–8 mm. in length, the other from 10 to 11 mm. The interambulacral spines of the bourrelets are slender and longer than those of the tubercles of corresponding size in other parts of the test. The somewhat distant primary radioles, are short, sharp, slender, and the intertubercular space of the whole test is thickly covered by secondary tubercles, carrying small, slender, straight radioles, usually having a slight cup-shaped extremity, which have been well figured by Thomson in the Echini of the Porcupine Expedition; he has also figured the pedicellariæ characteristic of this species. The principal large pedicellariæ are more closely allied by their structure to the Clypeastroid than to the Spatangoid types; in addition to these, there are also in the ambulacral areas more numerous pedicellariæ with short stout stems, quite similar to the secondary radioles but somewhat more slender, carrying a small trifid head set closely upon the cup-shaped extremity of the stalk. Minute long-stemmed, small-headed pedicellariæ are found near the actinostome in the ambulacral and interambulacral areas.

As the test increases in size its outline becomes more angular, the posterior extremity more elevated, and the Spatangoid features of the genus more apparent. There is, however, even in the largest specimen collected, no trace of petaloid ambulacra on the abactinal surface; the ambulacra retain as far as we know their simple embryonic structure. The apical system is compact, the genital openings are large, the left anterior and posterior genitals are atrophied. This was not the case either in the specimens collected by Thomson or in those previously dredged off Florida, in which the left anterior genital pore was wanting, in addition to the odd posterior one. In a specimen measuring 10 mm. in length there are two or three madreporic openings in the space between the genital openings. In Thomson's specimens, which are larger than any I have dredged, there are two such openings. I was unable to distinguish the line of sutures between the different genital plates. When covered with spines, the genital openings are protected by long secondary spines, and genital tubes are seen to project through the large openings beyond the level of the spines. Two or three, and sometimes four, sphæridia are found near the actinostome in each ambulacral area.

Echinolampas depressa Gray.

Yucatan Bank, Lesser Antilles. 82–101 fathoms.

Pl. XVI., Pl. XXIV. Figs. 1–5.

The Blake dredged in the Caribbean a number of specimens of this species. They are interesting as showing that the important modifications in the petaloid region of the ambulacral system, which characterize this and allied species in different stages of growth, make their appearance very early. In the younger stages I have figured (Revision of the Echini, Pl. XVI. Figs. 6, 7, 17, 18, 19, 21), the early development of the petaloid ambulacra and the unequal growth of the different poriferous zones of the ambulacra are quite striking. In a specimen measuring 37 mm. in longitudinal diameter, the left petaloid poriferous zone of the odd anterior ambulacrum is four pairs of pores shorter than the right. The anterior zone of the anterior ambulacra is fourteen pairs of pores shorter than the posterior zone, and the posterior zone of the lateral posterior ambulacra is seventeen pairs of pores shorter than the anterior zone. In a specimen measuring 45 mm. the difference in the number of pairs of pores between the same poriferous zones was greater by three in the anterior ambulacra, and less by four in the posterior ambulacra. This striking numerical difference still existed in specimens measuring no less than 50 mm. in length (Pl. XVI. Figs. 1, 3, 6), but is by no means constant, the difference between the number of pairs of pores in the anterior and posterior zones of the lateral ambulacra or in the right and left zones of the odd ambulacrum sometimes varying from the ratio stated above as much as four to six pairs. Similar differences in the length of the zones of the ambulacral petals are known in several recent and fossil species of the genus. This naturally suggests the propriety of subdividing the genus Echinolampas. This has been attempted in part by Bell, who has separated as Palæolampas a species of Echinolampas with straight ambulacral zones, and in which the outer rows of pores are the largest, and form with their rudimentary furrows embryonic petals. De Loriol has shown the difficulty of taking this character alone as basis for a generic division; but it would be convenient were we to take the living types alone, and subdivide the genus Echinolampas proper into sections, one containing the ovoid forms with distinctly petaloid ambulacra of equal length,

another containing those in which there is a marked difference in the length of the poriferous zones of the ambulacral petals, and a third, which Bell has called Palæolampas, characterized by the straight apetaloid ambulacral zones. The differences in the petaloid ambulacra are accompanied by other structural features, such as the position and outline of the anal system, and the character of the phyllodes and bourrelets, forming combinations of characters which a revision of the genus may show justify this subgeneric division. But as has been already pointed out by Cotteau and De Loriol, such a subdivision is impracticable if we take into account the numerous fossil species of Echinolampas. The subdivision of the genus to which *Echinolampas depressa* belongs is also marked by the absence of intercalated plates in the formation of the phyllodes (Pl. XVI. Fig. 4), and by the prominent apical button formed (Pl. XVI. Fig. 5) by the madreporic body, much as in Conoclypus. The characteristic uniform tuberculation of the test of *E. depressa* is seen in the different figures of Plate XVI. On the actinal surface there is a narrow band in the median ambulacral areas towards the actinostome. The abactinal surface of the test is covered by slender radioles; the radioles of the abactinal region are slightly shorter, increasing in length towards the ambitus, and becoming somewhat longer on the actinal side. The miliary spines are about a third of the length of the primary spines. When alive, the spines are of a greenish yellow color; the test, of a dirty yellow color. It is interesting to note that, of the many fossil species of Echinolampas described by Cotteau* from the West Indies, only two, *E. Castroi* and *E. Anguillæ*, show any marked difference in the length of the poriferous zones of the petaloid ambulacra.

On Pl. XXIV. is figured the youngest stage of Echinolampas I have seen. It measures 5 mm. in longitudinal diameter. The apical system is already eccentric; but in this stage the ambulacra are simple, showing no trace at the apex of rudimentary petals. The actinal system is circular, and the anal system is still on the posterior face of the test; the bourrelets are in the simplest form possible, a slight swelling of the ambulacral area at the actinostome, but the tuberculation is not different from that of the other part of the ambulacra.

* Cotteau, Ann. Soc. Géol. de Belgique, 1881, IX., Pl. II. Échinides Tertiaires des Isles St. Barthélemy et Anguilla, K. Vet. Akad. Handl., B. XIII., No. 6, Pl. IV., 1875.

Conolampas A. Ag.

Conoclypus A. Ag. Bull. M. C. Z., V., No. 9, p. 190, 1878 [non auct.].

* Conolampas Sigsbei A. Ag.

Conoclypus Sigsbei A. Ag. Bull. M. C. Z., V., No. 9, p. 190, Pls. I., II., 1878.
Yucatan Bank, off Havana, Lesser Antilles. 76–450 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 80, 1880.

Pl. XVII.

This magnificent species is by far the most striking Sea-urchin I have seen. I shall always remember the particular haul, when, on the edge of the Yucatan Bank, the dredge came up containing half a dozen of these huge brilliant lemon-colored Echini.

The test is covered by small primary tubercles of uniform size, quite regularly arranged on the plates of the test, both on the ambulacral and interambulacral areas. The tubercles on the actinal side are similarly arranged, with the exception of the vicinity of the ambitus, where they are more closely crowded together. The primary tubercles are surrounded by a deeply sunken scrobicular area, much as in Echinolampas and Rhynchopygus. The miliary tubercles are uniformly scattered between the primaries, and are separated by irregular transparent glassy ridges and elongated pits, much as we find them on the actinal side of Rhynchopygus; but near the ambitus on the actinal side, where the primary tubercles are most closely crowded, they are separated by closely packed secondary tubercles. The actinal bourrelets are very prominent; the floscelle is large, broad, well defined, extending nearly one third the distance from the actinostome to the ambitus. There are small, elongate, short-stemmed, slender pyramidal pedicellariæ scattered irregularly over the actinal surface; they are much less numerous on the sides of the test. The primary spines are short, slender, cylindrical, rapidly tapering at the extremity; the miliary and secondary spines are similar to the primary ones, but smaller. The apical system is compact, the genital plates all coalesce, the centre of the apex is occupied by the madreporic body, which is developed into a prominent knob, on the sides of which the ocular plates rise. There are four large genital openings; the odd posterior genital is wanting. The ambulacral zones are all identical in structure, two rows made up of distant pores extending two thirds

of the distance from the apex to the ambitus, forming the rudimentary petaloid ambulacra. At the extremity of these petals, the pores suddenly come close together, the poriferous zones becoming extremely narrow, and continue thus narrowed to the ambitus, and over to the actinal side, until they meet the floscelles. The anal system is covered by an outer row of three large plates and one smaller one, with a few smaller plates closing the outer edge of the anal system.

It was with considerable hesitation that I referred this species, when first described, to the genus Conoclypus. While it undoubtedly agreed with it in having a central apical system, a high conical test, and the five ambulacra of the abactinal side equally developed, yet the arrangement of the pores (Pl. XVII. Fig. 7) and the development of the phyllodes and of the bourrelets (Pl. XVII. Fig. 5), the transversely elliptical anal system (Pl. XVII. Fig. 6), and the structure of the apical system (Pl. XVII. Fig. 3), seemed to ally it more closely to Echinolampas. From the latter genus it differed, however, in the arrangement of the petaloid ambulacra, which do not form open petals as in the species of Echinolampas thus far known, but merely straight poriferous zones, not furrowed (Pl. XVII. Fig. 2), extending close to the ambitus. This feature alone would perhaps seem insufficient as a generic distinction, for we find in *E. depressa* of Gray that the ambulacral petals are modified somewhat from the characteristic Echinolampas type (*E. oviformis*), and besides not having closed petals, the poriferous zones of the different ambulacra are all of unequal length, somewhat as in *E. Alexandri* De Lor. (see Pl. XVI. Fig. 1), one of the characters by which Prof. F. J. Bell* attempted to separate the genus Palæolampas from Echinolampas. De Loriol† is of opinion that the characters on which Mr. Bell attempts to establish the genus Palæolampas are insufficient, yet we may find it convenient from the great variation we find in the petaloid areas of Echinolampas to adopt Palæolampas as a subgeneric type.‡

Zittel was the first to show, in his *Handbuch der Palæontologie* (I. 515), that some species of the genus Conoclypus possessed teeth. This led De Loriol to make an examination of this genus, and he found that it really contained two generic types, one with phyllodes, which was edentate, and another in which there is no trace of phyllodes, but an enormous development of the bourrelets, which is provided with teeth. For the first type

* Proc. Zoöl. Soc. London, 1880, p. 43.

† Mém. de la Soc. de Phys. et d'Hist. Nat. de Genève, 1880, XXVII. 88.

‡ See page 46.

De Loriol has proposed the name of Phylloclypeus.* These discoveries led me to make a renewed examination of *Conoclypus Sigsbei*. On opening a specimen I found that it was edentate, as had been suggested by De Loriol from the presence of the well-developed phyllodes (Pl. XVII. Fig. 5) characteristic of Echinolampas and of the edentate Conoclypus type he called Phylloclypeus. On comparing the structure of the actinostome in *Conoclypus Sigsbei*, as seen from the interior, with that of Echinolampas, I found very striking differences. As is well known, in *Echinolampas Hellei* (Pl. XV. Fig. 9, Rev. Echini) the test immediately round the actinal opening rises slightly, in a conical shape, above the general level of the actinal floor. This is also the case in *E. depressa*, but in both cases the edges of this conical elevation form a smooth ring round the actinostome, the cone being in fact merely the turning up of the outer edges of the last plates immediately adjoining the actinostome. In *Conoclypus Sigsbei*, on the contrary, the structure of the ring of plates round the actinostome is quite similar to that described by Zittel and De Loriol in Conoclypus with teeth; the processes which support the jaws, although wanting (Pl. XVII. Fig. 4), are still indicated by slight angular knobs, and we also find the deep pits described by these authors in the interambulacral areas at the base of this elevated ring.

This structural feature is one of the most interesting found among Echini, as it seems to show us the direct passage, as it were, between the edentate Echini and those provided with teeth. We have no full description as yet of the jaws of Conoclypus, but enough is known to show us how closely allied they are to those of the Clypeastroids. In Conoclypus they are evidently held in place by vertical processes, very similar to those which thus far have been considered as characteristic of the Clypeastroids. With the diminution in size of the jaws in these types we must expect to find genera in which the supporting processes alone are left, and we may look for them in the forms allied to the genus Phylloclypeus of De Loriol. The next stage will be the practical disappearance of these processes, their former presence being indicated by mere knobs, as in *Conoclypus Sigsbei*, until we get the typical modern Echinolampas, in which the plates forming the actinal ring rise only as a low cone above the general level of the actinal floor, and all traces of these processes and of the interambulacral actinal pits have disappeared. It may be convenient for the present to call this modern rep-

* Mém. de la Soc. de Phys. et d'Hist. Nat. de Genève, 1880, XXVII. 79.

resentative of the Conoclypei, with its central apex and characteristic ambulacra, by the name Conolampas, until we know more of the structure of the interior of the actinostome of the Cretaceous genus Phylloclypeus of De Loriol, as well as of the species of Echinolampas with high test, to which this species of Conolampas may perhaps be more closely related than now appears. Cotteau has figured such a species of Echinolampas (*E. semiorbis*, Guppy) from the Eocene of St. Barthélemy, and he likewise calls attention to its resemblance to several species of Conoclypus.

As I have already stated in the Preliminary Report of the Blake Echini (Bull. M. C. Z., V., No. 9, p. 191), I described in the Revision of the Echini, and figured on Pl. XVI. of that work, several stages of the young of Conolampas (*Conoclypus Sigsbei* A. Ag.) as the young of Echinolampas. I had not at that time dredged Conolampas, and was thus misled, by the examination I had made of only a few young stages either of Echinolampas or of Conolampas, to consider them all as belonging to the same genus.

Additional young specimens of Echinolampas and of Conolampas having been obtained in the Caribbean by the Blake, I am now able to rectify my error, and, by referring to the figures given on Plate XVI. of the Revision, to indicate those which belong to Echinolampas, and those which represent young stages of Conolampas.

It will be seen that in corresponding stages of growth of these two genera we find in one case, in young specimens of Echinolampas, already the first trace of the peculiar petaloid development of the ambulacra characteristic of this species (Pl. XVI. Figs. 6, 7, Rev. Echini); while in the corresponding young stages of Conolampas (Pl. XVI. Figs. 4, 11, 12, Rev. Echini) the ambulacra have the characteristic structure of the genus. To recapitulate, Figs. 6, 7, 17, 18, 19, 21, of Plate XVI. of the Revision, belong to Echinolampas, while Figs. 1–5 and 8–16 of the same plate belong to the young stages of Conolampas.

The Pygaster or Echinoconus* stage, if I may so call it, of both Echinolampas and Conolampas, appears to be a most characteristic stage of these genera, and it is possible that the recent species mentioned by Lovén as *Pygaster relictus*, may after all only be a young stage either of Echinolampas or of Conolampas. This is very probable judging from the size of Lovén's specimen, 3 mm. in diameter, and from its origin, the Virgin Islands.

* See the excellent figures of a fine series of Echinoconus given by Cotteau in Bull. Soc. des Scien. Hist. et Nat. de l'Yonne, (2,) IV., 1881, Pl. I.

Pourtalesia miranda A. Ag.

Off Havana, Grenada. 242–576 fathoms.

The fragments of other Pourtalesiæ, dredged principally off the Barbados, to which I referred in Bull. M. C. Z., VIII., No. 2, p. 80, 1880, belong probably to the genera Cystechinus and Spatagocystis. The fragments are too imperfect for determination, and have no value beyond the fact that they indicate the presence of other species of the group in the West Indies.

Urechinus naresianus A. Ag.

Lesser Antilles, Lat. 41° 24′ 45″ N., Long. 65° 35′ 30″ W. 422–1242 fathoms.

Pl. XXVI. Figs. 1–3.

The greater part of the specimens collected by the Blake measured about 30 mm. in length, but varied greatly in height. They agree quite closely with what I have designated as the normal stage in the Report of the Challenger Echini. (See Chall. Ech., Pl. XXX^{a}. Figs. 7–9, p. 146.) The specimens examined all show but three genital openings. The structure of the subanal fasciole shows that in this genus it assumes all the stages of development intermediate between a well-defined subanal plastron, such as is figured on Plate XXX^{a}. of the Challenger Echini Report, and a stage in which this fasciole is indicated merely by irregular accumulations of miliary tubercles. So that the genus Urechinus is the representative of the oldest Spatangoids with a disconnected apical system, large ambulacral and interambulacral plates with simple linear ambulacral pores, in which the subanal fasciole (the only one existing) is still in process of formation; this type of Spatangoid leading us little by little to Spatangoid genera in which the ambulacra become more or less petaloid, as in Homolampas, Paleopneustes, and the like, till we get the modern type of Spatangus proper, with well-defined petaloid ambulacra, and a highly developed subanal fasciole, the lateral fasciole existing in some of these genera, Paleopneustes, Linopneustes, Calymne, Maretia, etc., in a rudimentary form, as accumulations of miliary tubercles along the ambitus. On the other hand, a slender peripetalous fasciole is in some genera, Paleopneustes, Homolampas, Rhinobrissus, etc., developed as a slender thread, or as a more or less well-defined fasciole extending across the termination of the more or less rudimentary petals.

We find the lateral fasciole developed from the peripetalous fasciole in

such genera as Hemiaster, Rhinobrissus, Linthia, Schizaster, etc., on the one side; and on the other, in such genera as Paleopneustes, Maretia, Linopneustes, Homolampas, etc., we find the more or less rudimentary lateral fasciole plainly developed from the anal or branches of the subanal fasciole, or independently.

This corresponds fairly well with the two series we find among the fossil genera, in one of which the lateral fasciole is the appendage of the peripetalous fasciole, and in the other of the fasciole of the anal system, or has arisen entirely independently as an ambital lateral fasciole, if I may so call it.

Palæotropus Josephinæ Lovén.

Off Havana, Lesser Antilles. 82–242 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 81, 1880.

Pl. XXIII. Figs. 5–14.

A small specimen 10 mm. long did not differ from that figured by Lovén (Pl. XIII. Figs. 108–113, *Études sur les Échinoïdées*). Older specimens measuring 23 mm. in length, figured on Plate XXIII., are comparatively less globular and more flattened, but otherwise do not vary greatly in appearance from the younger specimens. In the Preliminary Report* on this collection I had referred a few larger Spatangoids to this species; but on denuding them from spines I find that they have nothing in common with Palæotropus, and they are described in this Report as belonging to a new genus (Palæobrissus) intermediate between Platybrissus and Argopatagus.

The test of this species is comparatively bare (Pl. XXIII. Figs. 5–11), carrying but few primary spines; these are generally straight, with a smooth shaft, only a few of the very largest spines being slightly serrated. The miliaries and secondaries are more numerous, generally club-shaped at the extremity, often curved, and many of them with serrated shafts. The miliary tubercles of the anal fasciole carry comparatively long, slender, slightly club-shaped spines.

The coloring of small specimens is of a greenish violet, the whole test being irregularly covered with distant dark violet pigment-spots. With increasing size these spots become less numerous, concentrating mainly about the base of the primary spines.

* Bull. M. C. Z., VIII., No. 2, p. 81.

There is little difference in the arrangement of the ambulacral plates in older or younger specimens. The two large genital openings, already present in the youngest specimens known, have greatly increased in size, and the madreporic openings are better developed in larger specimens (Pl. XXIII. Fig. 12). The mode of formation of what has been called a compact abactinal system is admirably shown in the structure of the apex of Palæotropus, in which the exterior sutures of all the plates adjoining the interambulacral areas are most distinct, while the interior junction of the genital plates has become completely obliterated (Pl. XXIII. Fig. 12), they being still separated by the odd imperforate genital plate which is intercalated between them, and of which the posterior and lateral sutures are still well marked, while the interior anterior sutures are no longer visible. In Palæobrissus the sutures of all the plates of the apex can be distinctly detected.

In the youngest stages, as well as the larger, we find near the actinostome in each ambulacral area one or two unusually elongate sphæridia. They have a comparatively long reticulated stem, and it is interesting to note that in some of the larger specimens we find near the ambitus on the actinal side peculiar miliary spines which I am inclined to consider as modified sphæridia. These peculiar spines have the shaft of a miliary, but the tip is swollen out to a clear sphere resembling in all respects the head of sphæridia, of which the base of attachment is usually merely rudimentary, as described by Lovén; in addition we have such types as the sphæridia typical of the actinal side of the genus Palæotropus. This would seem to show that the sphæridia, like the pedicellariæ, the spines of the fascioles, and perhaps other appendages of the test of Echini, are only modified forms of spines.

Danielssen and Koren* have figured peculiar spines of Hymenaster, which also throw considerable light on the nature of the sphæridia. They are clusters of reticulations at the base of a central shaft, much like the reticulations figured by Lovén as characteristic of the base of sphæridia. These spines are surrounded by a bag-like pouch representing undoubtedly for Starfishes the bag-like appendages of certain spines of Asthenosoma and Aspidodiadema, which in their turn seem to have close affinities with the peculiar gland of certain Echinid pedicellariæ described by Sladen and others, as I have already noticed in the description of some remarkable spines occurring on the test of Aspidodiadema.

* Plate II. Figs. 2, 3, Nyt. Mag. for Naturvid., XXVIII.

In the larger specimens of *Palæotropus Josephinæ* there is a slight tendency to the formation of very rudimentary bourrelets. The larger outer plates of the actinal system carry a few minute miliary tubercles and spines. (Pl. XXIII. Fig. 14.) On the abactinal surface the ambulacral suckers are slender, surmounted by a small indistinct sucker, the tentacles increase in size towards the ambitus, and near the actinostome there are four or five large fimbriated tentacles in each ambulacral area.

The pedicellariæ are most varied, representing types characteristic of the Clypeastroids as well as the Spatangoids. On the actinal side there are in the ambulacra, near the outer edges, minute slender, long-stemmed, two-jointed pedicellariæ with small pear-shaped trifid heads. At the ambitus, interspersed among the preceding, are short-stemmed, large-headed, stout pedicellariæ resembling the Clypeastroid types. In the bare interambulacral spaces there are a few large-headed, short-stemmed, trifid pedicellariæ, some with short prongs, others with long crossing prongs. Scattered irregularly over the abactinal surface are few distant triangular-headed trifid pedicellariæ, with long, slender stems, and short, flexible head-joints. The heads of these last pedicellariæ are of two very different sizes, but otherwise they do not differ.

* Palæotropus Thomsoni A. Ag.

Palæotropus Thomsoni A. Ag. Bull. M. C. Z., VIII., No. 2, p. 80, 1880.
Lat. 32° 43′ 25″ N., Long. 77° 20′ 30″ W. 233 fathoms.

At Station 321 a single broken specimen of this species was collected, which differs most strikingly from all the other specimens of Palæotropus. It is closely covered by uniform tubercles on the abactinal side. It has a proportionally greater number of coronal plates, and a high test, with a keeled posterior interambulacral median line. Apex more posterior than in *P. Josephinæ*.

The color of the test is yellowish white when alive. The large *P. Josephinæ* are of a dirty greenish red color, and when young more pinkish. This species is also remarkable for its broad, bare posterior lateral ambulacra on the abactinal side, and for its prominent keeled, very elongate actinal plastron, and its longitudinally elongate anal fasciole, still very prominent at a time when in *P. Josephinæ* the posterior extremity has become flattened, and the fasciole quite indistinct.

* Palæobrissus Hilgardi A. Ag.

Station No. 300. 82 fathoms, Barbados.
Station No. 295. 185 fathoms, Barbados.

Pl. XXIV. Figs. 6–15.

At the time of writing the Preliminary Report on the Echini of the Blake cruise in the Caribbean, the specimens of this species were not distinguished in the first examination from *Palæotropus Josephinæ*, to which they have, when covered with spines, a general resemblance both in shape and coloring (Pl. XXIV. Figs. 6–8). Palæobrissus is one of the most interesting generic types collected by the Blake. From the structure of its ambulacra it is closely allied to both Platybrissus, Nacopatagus, and Argopatagus. The ambulacra are not petaloid, as in the former genus. The pores of the lateral ambulacra are arranged in straight, double, diverging rows (Pl. XXIV. Fig. 10). The pairs of minute pores of the abactinal region increase rapidly in size towards the extremity of the rudimentary petals, the last four pairs being large and well separated, the outer pore of each pair slightly larger than the inner one; the lateral ambulacral petals extend nearly to the ambitus (Pl. XXIV. Figs. 11, 12). The odd anterior ambulacrum is not as prominently developed as the lateral ambulacra, the pores remaining all small (Pl. XXIV. Fig. 10). There are four genital pores (Pl. XXIV. Fig. 15), the anterior pair the smallest, separated from each other by the well-marked madreporic pores, which conceal the sutures between the anterior genital plates. The posterior genital plates are comparatively large, adjacent, becoming intercalated with the median posterior interambulacral plates. The anterior part of these genital plates is perforated by the large elliptical posterior genital pores. The structure of the apical system of this genus shows how the abactinal interambulacral plates are derived from the terminal plates of a compact apical system; these are not necessarily the genital plates, but may be intercalated plates formed from the subdivision of any of the abactinal interambulacral plates at the apical junction of the posterior lateral interambulacra with the odd interambulacrum.

The upper part of the test (Pl. XXIV. Fig. 10) is covered by small primary tubercles of uniform size, somewhat distant, quite regularly arranged on the plates, increasing in number towards the ambitus. The intertubercular space is filled by distant miliaries, also quite uniformly scattered over

the test. The primary spines are small, slender, and straight. The miliary spines, similar in structure to the primaries, are not more than a third to a quarter their length. When covered with spines, the coloring is of a dark greenish violet; denuded, the test is of a pinkish gray.

On the actinal side (Pl. XXIV. Fig. 9) the primary tubercles are more closely packed in the interambulacral areas and on the actinal plastron, but the anterior ambulacral plates towards the actinostome, as well as the posterior lateral ambulacral areas on each side of the actinal plastron, are left bare. The posterior lip of the actinostome is but slightly developed (Pl. XXIV. Figs. 9, 13); there is a tendency to the formation of rudimentary bourrelets from the crowding of small secondary tubercles on the interambulacral edges of the actinostome (Pl. XXIV. Fig. 13). The anterior part of the actinal opening is covered by eight large polygonal plates of irregular outline; the remaining space on the posterior part of the actinostome along the actinal lip (Pl. XXIV. Fig. 13) is covered by smaller irregularly arranged plates. The actinal plates all carry minute secondary tubercles.

The anal system (Pl. XXIV. Fig. 14) is circular, surrounded by two or three concentric rows of irregularly arranged plates.

The large actinal tentacles are fimbriated; towards the ambitus and beyond it, until they reach the extremity of the petals, they become simple with a slight sucker. The tentacles of the petaloid region are broad, flattened, with an indistinct sucking disk.

The ambulacra carry, as in Palæotropus, short-stemmed, stout-headed, and short-stemmed, large-headed trifid pedicellariæ. Scattered irregularly over the test are long-stemmed, large, slender, open-headed trifid pedicellariæ.

Homolampas fragilis A. Ag.

Homolampas fragilis A. Ag. Bull. M. C. Z., V., No. 9, p. 191, 1878.
Florida Bank, Lesser Antilles. 734–1920 fathoms.

Fragments of a large specimen of Homolampas, very probably the adult of *H. fragilis* A. Ag., of which young specimens were dredged by Mr. Pourtalès (see Revision of the Echini, Pl. XVII. Figs. 13–21). These fragments show *H. fragilis* to be closely allied to the large species of the same genus (*H. fulva*, A. Ag.) described and figured in the Report on the Echinoidea of the Challenger (Pl. XXIV.). The Caribbean species differs from it, however, by the closer tuberculation of the miliaries, the larger number of primary

tubercles in the interambulacral areas near the abactinal system, and the coarser tuberculation of the odd anterior groove above the ambitus; also in having a larger number of primary plates. No part of the anal system or of the actinal system was found among the fragments.

Paleopneustes cristatus A. Ag.

Off Havana, S. side of Cuba, Lesser Antilles. 56–450 fathoms.
Most common to the leeward of the West India Islands, between 90 and 150 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 81, 1880.

Pl. XXI.

A number of specimens of this species have been collected by the Blake, which are interesting as throwing additional light on the variability of the so-called lateral fasciole of this genus, and in showing the changes due to growth. Thus far only large specimens of this genus had been described, both from the Hassler and the Challenger expeditions. I have added to the figures of two of the principal stages of growth given on Plate XXI. Figs. 6–14, details of the actinostome (Fig. 5), of the apical system (Fig. 3), of the termination of the lateral petaloid ambulacra (Fig. 1), of the edge of the test near the ambitus from the abactinal side (Fig. 2), taken from a large specimen of this species measuring nearly 150 mm. in length and 80 mm. in height, as these details could not be very clearly seen in the photographic illustrations of this species in the Memoir on the Echini of the Hassler Expedition (Pl. IV. Figs. 1–3, Ill. Cat. M. C. Z., No. 8).

A small specimen measuring 45 mm. in length (Pl. XXI. Fig. 7) differed from the specimen figured in the Hassler Echini merely in size, and in having an indistinct lateral fasciole extending obliquely from the abactinal end of the anal system to the edge of the test, reaching the ambitus at the anterior lateral ambulacra, and extending faintly across the anterior part of the test along the ambitus. See Plate XXI. Fig. 7, and Fig. 8, which shows a small part of this fasciole close to the ambitus across the anterior ambulacral area. This can hardly be termed a lateral fasciole; it reminds us of a similar fasciole in Calymne, and it is difficult to decide in these cases whether this single fasciole should be called peripetalous as it passes across the posterior extremity of the test above the anal system, or a lateral fasciole occurring isolated from a peripetalous one; or whether it represents a rudimentary stage of the peripetalous fasciole, not crossing the ambulacra

at the extremity of the petaloid ambulacra or the petals themselves, as in one of the species of Rhinobrissus, but crossing them below the petals at an indefinite place of the test; so that we might have an interior fasciole, as in Lovenia; a true peripetalous fasciole, as in Hemiaster; a transpetaloid fasciole, as in Gualteria and Rhinobrissus; or a marginal fasciole, as in some stages of growth of Paleopneustes and in Linopneustes; all representing different stages of development or modification of a petaloid fasciole. This simple series becomes complicated with the possible simultaneous existence of an internal and peripetalous fasciole or of a true peripetalous fasciole with a more or less marginal fasciole, forming in that case a lateral fasciole proper. In a specimen of this species measuring about 85 mm. in length, the marginal fasciole is traced only with difficulty near the ambitus across the anterior lateral ambulacra (Pl. XXI. Fig. 8), and it seems to disappear completely in somewhat older specimens. But in all the stages of growth that part of the ambitus and of the test adjoining the course of the marginal fasciole is thickly studded with miliaries and small secondary tubercles (Pl. XXI. Figs. 2, 6, 8).

In Linopneustes this marginal fasciole has assumed practically all the characters of a peripetalous fasciole crossing the posterior lateral ambulacra just at the end of the petals, while it still crosses the anterior ambulacra a short distance below the end of the petals. Neither in *Paleopneustes cristatus* nor in *P. hystrix* do we find any trace of a rudimentary subanal fasciole, either as an indistinct band or a part of a band, or even as accumulations of miliary tubercles; and it is interesting to note that in species so closely allied as *P. cristatus* and *Linopneustes Murrayi* there should be so striking a distinguishing feature as the presence or absence of a subanal fasciole, while in other genera of Spatangoids, Palæotropus, Urechinus, and Schizaster, in specimens of the same species, such as *Urechinus naresianus*, we should have a complete series passing from a well-defined subanal fasciole to a mere accumulation of miliary tubercles.

The smallest specimen collected, measuring about 16 mm. in length, is somewhat more flattened than the older stages, and shows as yet no trace of petals, the ambulacral plates and pores extending uniformly from the apex to the ambitus and actinostome without the specialization of any portion. (Pl. XXI. Figs. 9–11.) In this stage I could see no indication of a marginal fasciole. The apex was compact, but there was no trace as yet of any genital openings, and the madreporic body was very faintly indicated (Pl.

XXI. Fig. 12). In the apical system of the large specimen figured here (Pl. XXI. Fig. 3), the madreporic body covers nearly the whole of the space between the genital plates; the two left anterior plates, as well as the right posterior plate, are adjacent and perforated.

In the specimen measuring 45 mm. in length the apical system, as well as the anal system and the actinostome, had already assumed all the characteristic features of the larger and older specimens.

In the smallest specimen the actinostome is quite pentagonal (Pl. XXI. Fig. 13), and the posterior actinal lip only slightly indicated. The plates covering both the actinal opening and the anal system do not differ greatly in number in the older and very young specimens (compare Pl. XXI. Figs. 13, 14, and Figs. 4, 5). The few comparatively large and distant primary tubercles of the interambulacral plates (Pl. XXI. Figs. 9, 10) give to the young Paleopneustes a very different facies from its older stages.

* Paleopneustes hystrix A. Ag.

Paleopneustes hystrix A. Ag. Bull. M. C. Z., VIII., No. 2, p. 82, 1880.
Saba Bank, Guadeloupe. 21–208 fathoms.

Pl. XVIII., Pl. XIX. Fig. 2 (lower figure).

Seen in profile (Pl. XIX. Fig. 2) this species is flatter and has a more conical outline than *P. cristatus*. I know of no Spatangoid which has such large, stout primary spines as those which cover the interambulacral areas of the abactinal side of the test, though in Lovenia they are longer, and in Linopneustes they are as long but not as stout. They resemble more in appearance the spines of a large specimen of *Echinus aculus* than of a Spatangoid. They are straight, comparatively stout, some of the primary spines measuring in length nearly a fourth of the test. These large spines are carried on distant tubercles, not more than three in each of the larger interambulacral plates of the abactinal surface near the ambitus, and only two towards the apical system. Four or five small secondary tubercles irregularly placed on the plates, with distant minute miliary tubercles, compose the whole tuberculation of the interambulacral part of the test (Pl. XVIII. Fig. 2). The ambulacra carry no primary tubercles, only distant miliaries and a few small secondary tubercles in the median interpetaloid space. Below the petals the ambulacral plates carry one large primary tubercle

surrounded by four or five secondaries with the same scattering of distant miliaries.

The secondary spines of the abactinal surface are small, slender, sharp, short, slightly curved, about 5 mm. in length; the delicate miliary spines are about half that length. Toward the ambitus the tuberculation becomes closer, and on the actinal side (Pl. XVIII. Fig. 5) the primary tubercles are somewhat smaller and arranged in three irregular horizontal rows, quite closely packed on the interambulacral plates, with only a few scattered secondary tubercles and less numerous miliaries than on the abactinal surface. This tuberculation extends also over the ambulacral plates on the actinal side, so that in this species there is nothing of the broad bare ambulacral avenues, extending from the ambitus to the actinostome found in other species of this and allied genera. On the actinal side the spines are proportionally smaller, more slender, shorter, slightly curved and spathiform, as in other Spatangoids.

The phyllodes (Pl. XVIII. Figs. 5, 6, 7) are remarkably prominent in this species, and the actinostome is larger in proportion to the diameter of the test than in *P. cristatus*. In a specimen measuring 115 mm. in length, the actinal opening measures 25 mm., while in a specimen of *P. cristatus* measuring 144 mm. in length the actinostome measures only 27 mm. The other principal differences of *P. hystrix* from *P. cristatus* are seen in the abactinal system and the ambulacral petals. There are four genital openings; but in some specimens the left anterior genital is not as fully developed as the others. It is therefore probable that in some cases we may find only three genital pores, as in *P. cristatus*. The ambulacral plates are comparatively higher and wider than in *P. cristatus;* in addition, the pairs of pores are placed nearer the outer edges of the ambulacral plates than in *P. cristatus*, where they are situated nearly in the centre of the plates. This causes the semi-petaloid part of the ambulacra to diverge more rapidly than in the other species of the genus, the pairs of pores at the lower extremity of the petals being nearly twice as distant as in *P. cristatus*. There is considerable variation in the size of the pores of the petaloid ambulacra; as a general rule, on the outer rows, the pores are comma-shaped and much larger than the comparatively small pores of the inner rows, but in other specimens this difference is not so striking. When alive the color of the test varies greatly; it is in some specimens of a rich light chocolate color, from which stand out in striking contrast the long yel-

lowish gray primary spines of the abactinal surface; in others, the test and spines are of a greenish purple, the most common coloring of the test being a light Indian-red with primary spines of the same tint.

* Linopneustes longispinus A. Ag.

Linopneustes longispinus, A. Ag. Bull. M. C. Z., VIII., No. 2, p. 82, 1880.
Eupatagus longispinus A. Ag. Bull. M. C. Z., V., No. 9, p. 191, 1878.
Off Havana, Lesser Antilles. 38–250 fathoms.

Pl. XIX. Fig. 1 (upper fig.); *Pl. XX.*

This species was first noticed as *Eupatagus longispinus*, from a number of somewhat imperfect fragments, showing this large Spatangoid to be related to Eupatagus, Platybrissus, and Paleopneustes. A number of specimens since collected off the West India Islands show that it is closely allied to *Linopneustes Murrayi*.

The test of this species is depressed, apex slightly anterior. It holds in the genus Linopneustes the same relation to *L. Murrayi* which *Paleopneustes hystrix* holds to *P. cristatus*. Both *P. cristatus* and *L. Murrayi* are covered on the abactinal side with a close tuberculation, carrying comparatively small, stout, slender primary spines; while *P. hystrix* and *L. longispinus* both are characterized by the few and comparatively large primary tubercles seated on the plates of the interambulacral areas of the abactinal surface. In all the specimens I have examined, varying from 65 to 110 mm. in length, the marginal fasciole (Pl. XIX. Fig. 1) is most prominent, forming a narrow band carrying minute dark-colored miliary spines all round the abactinal ambital edge (Pl. XX. Fig. 8) of the test, passing at the posterior extremity close to the upper part of the anal system. In this respect the course of the fasciole of this species of the genus Linopneustes differs strikingly from the tertiary Pericosmus, in which the marginal fasciole follows the same course close to the ambitus, but its posterior extremity passes under the anal system. Desor has called attention to the variability of this fasciole, which in the fossil species of the genus Pericosmus appears to be often as ill defined and as variable as in the recent species of Linopneustes.

The subanal fasciole of *Linopneustes longispinus* (Pl. XX. Fig. 8) is transversely elliptical, irregularly hexagonal with rounded corners, and narrower than the corresponding fasciole of *L. Murrayi*. The anal system is also

comparatively smaller, and covered by smaller plates than in that species, and is transversely elliptical. The apical system in both the species of Linopneustes is more compact than in Paleopneustes.

The odd anterior ambulacrum of *L. longispinus* is more sunken at the ambitus than in the Japanese species. The lateral ambulacra are more petaloid than in any other species of either Linopneustes or Paleopneustes thus far known; in some specimens they end at the extremity much as they do in Eupatagus. (Pl. XX. Fig. 1.) The petaloid pores of the two rows are of nearly the same size, placed close together on the outer edge of the ambulacral plates. The petals extend somewhat more than half-way from the apex to the ambitus. The secondary tubercles are small, of uniform size, and the whole surface of the test is uniformly covered by minute miliaries. The primary spines of the abactinal surface are long, slender, curved, (Pl. XIX. Fig. 1, Pl. XX. Fig. 1,) some of them measuring nearly a quarter of the test in length. The thin slender and straight secondary spines are not more than 3 or 4 mm. long; the thin hair-like miliary spines are nearly as long, and are generally curved.

On the actinal side of the test the primary tuberculation is close in the posterior lateral interambulacral areas on one or two plates near the ambitus, but towards the actinostome the primary tubercles increase in size (Pl. XX. Fig. 5), and at the same time become less numerous. The tuberculation of the actinal plastron is smallest along the median line, the tubercles increasing in size towards the outer lateral edge adjoining the broad bare posterior interambulacral areas. The spines of the actinal surface are shorter and more slender than those of the abactinal surface; they are curved, and those adjoining the bare posterior ambulacral zones are more spathiform than the spines on the rest of the actinal surface. The actinostome of this species is comparatively smaller (Pl. XX. Fig. 6) than that of *L. Murrayi*, measuring only 10 mm. in longitudinal diameter in a large specimen of 105 mm., while in one of *L. Murrayi* of 85 mm. the actinostome measures nearly 15 mm.

When alive, the test is pinkish or flesh-colored, the large primary spines of the abactinal surface having a yellowish tint with a whitish silvery lustre.

* Macropneustes spatangoides A. Ag.

Spatangus purpureus A. Ag. (non Leske nec auct.). Bull. M. C. Z., VIII., No. 2, p. 83, 1880.
Lesser Antilles. 82–373 fathoms.

Pl. XXVII.

The fragments of the Spatangoid which I referred in the Preliminary Report to *Spatangus purpureus*, I find on closer examination to belong to the genus Macropneustes. Although no complete living specimen was dredged, yet a sufficient number of dead broken tests were collected to enable me to restore this species satisfactorily, with the exception of the part near the anal system. In general appearance and outline, as seen from above, this species resembles *Spatangus purpureus;* but it can at once be distinguished by the high anterior part of the test, which in the abactinal part of the odd ambulacrum rises above the apical system.

The anterior ambulacrum is deeply sunken at the ambitus, in a groove similar to that of *Linopneustes longispinus*. In old specimens the abactinal part of the ambulacral petals are disconnected, much as in Echinocardium, within the internal fasciole. On the actinal surface the tuberculation is quite uniform in specimens of very different sizes. The larger primary tubercles are found on the anterior part of the test, and in the posterior interambulacral area they diminish gradually in size towards the posterior extremity, and become more closely crowded. The tubercles of the actinal plastron are smaller and of uniform size. On the abactinal surface the primary tubercles are limited to the interambulacral areas within the peripetalous fasciole, except along the line of the middle of the posterior interambulacral area, along which the V-shaped angular lines of primary and secondary tubercles extend, gradually diminishing in size towards the anal system. Within the peripetalous fasciole the arrangement of the primaries varies greatly. In some specimens there are not more than nine or ten large tubercles in the apical part of the interambulacral areas; in others the primary tubercles form V-shaped figures in each plate, the smaller tubercles on the lower side of the plates. In other specimens, again, the large tubercles form merely irregular horizontal lines. The rest of the surface of the test within the petaloid area to the actinal side is closely packed with small miliary tubercles, often concentrated more or less on the lower part of the coronal plates so as to form V-shaped areas. The petaloid ambulacra

are closed at the extremity, the anterior pair is considerably larger than the posterior pair. The outer rows of pores are the largest in both lateral petals. The pairs of pores are sunken. The odd anterior ambulacrum consists of lines of single pores, one for each ambulacral plate. Apical system compact, with four genital openings and small madreporic body.

The most interesting structural feature of this genus is the composition of the peripetalous fasciole, and the light which this throws on the possible origin of the fascioles as a whole. As is well known, in Macropneustes the peripetalous fasciole forms a clear, simple narrow band around the extremity of the petals. This we find to be the case also in some specimens of this species of Macropneustes. In others, the anterior part of the fasciole beyond the extremity of the anterior petals becomes indistinct or disappears. In still other specimens, the posterior part of the fasciole across the odd interambulacral area widens, forming elongated V-shaped areas: sometimes there are two or three such areas. In other cases a similar structure extends across the lateral ambulacra. In other cases, again, only a few such disconnected V-shaped areas take the place of the fasciole; as these become less numerous and more indistinct, the fasciole disappears completely. These V-shaped areas form as it were secondary posterior and lateral branches of the peripetalous fascioles, similar to the anterior bands observed by Troschel in Tripylus. Across the anterior ambulacrum there are sometimes no less than six or seven such secondary fascioles, some of the upper branches uniting again with the main fasciole, others extending parallel to the ambitus across the ambulacra into the lateral ambulacra, where the extremities die out in the crowded miliary tubercles covering that part of the test. In some of the specimens the miliaries of the lateral ambulacral and interambulacral areas below the peripetalous fascioles show a tendency to be crowded towards the lower edges of the plates, thus forming indistinct V-shaped areas resembling somewhat the V-shaped areas of the secondary fascioles, but made up of course of larger tubercles. This suggests the question whether the bare sutural bands characteristic of some of the genera of Cidaridæ, Arbaciadæ, Temnopleuridæ, and other Echinoids, are not the first trace of fascioles. So that we may consider the concentration of the miliary and secondary miliary tubercles on the edges of certain plates, or in the centre, so as to form bare sutural lines or bands along certain parts of the test, either in the ambulacral or interambulacral areas, as the first indication of the formation of fascioles, or as rudimentary or disconnected fascioles.

This concentration of the secondary miliaries seems in some other genera to take place in old specimens. This is particularly well shown in large specimens of *Metalia pectoralis* (see Pl. XXI. Fig. 5, Revision of the Echini); in small specimens measuring not more than half the size of the one figured, this structure is very indefinite. In some large specimens of *Spatangus purpureus* a slight tendency to a similar concentration of the secondary miliaries could also be detected.

The anal system is transversely elliptical, measuring 16 mm. in a specimen of 95 mm. in length. In the same specimen, the subanal fasciole is broad, enclosing a somewhat heart-shaped area vertically elongate, measuring about 17 mm. along its greatest diameter.

* Hemiaster Mentzi A. Ag.

Hemiaster Mentzi A. Ag. Bull. M. C. Z., VIII., No. 2, p. 83, 1880.
Lesser Antilles. 170–626 fathoms.

This small species is characterized by the globular outline of the test, and by the narrow, comparatively elongate space included within the peripetalous fasciole. It has a larger number of buccal plates than *H. gibbosus*. The tuberculation is coarser and more distant than in that species, more as it is in *H. zonatus* and *H. expergitus*. As in the latter species, the posterior extremity of the test is vertically truncated nearly flush with the rest of the test, the anal system but slightly sunken, with a mere trace of an anal groove. The test forms over the abactinal part of the anal system a very rudimentary hood. This species is also remarkable for the great development of the suckers of the odd anterior ambulacrum. In a specimen measuring 17 mm. in length the suckers still retain the prominence they have in very young Spatangoids. (See the figure of young Brissopsis in Rev. Echini, Pl. XIX. Figs. 1, 2.) This embryonic character is not the only one this species retains; its globular form, the position of the peripetalous fasciole near the abactinal system, the short comparatively simple petaloid lateral ambulacra, are all features it has in common with the young of other Spatangoid genera. In the only other species of the genus of which the changes due to growth have been traced (*Hemiaster cavernosus*, Challenger Echini, Pl. XX^{a}. Figs. 7–14), the odd anterior ambulacrum does not assume the great prominence it has in the young of this species. In a small specimen of *H. Mentzi*, measuring 7 mm. in length, the peripetalous

fasciole is broad, elliptical, and the greater part of the space it encloses is filled by the huge suckers of the odd anterior ambulacrum. The close resemblance of this stage of Hemiaster to an Aërope is very marked, and the permanence of the unusual development of the tentacles of this odd anterior ambulacrum up to the adult stage is an important link in tracing the affinities of such widely separated genera as Hemiaster, Brissopsis, Agassizia, Aërope, Aceste, and Schizaster.

The structure of the larger interambulacral spines in the young stages (7 mm. long. diameter) well shows the manner in which the fantastic shape of some of the Spatangoid spines is produced. The outer sheath of calcareous rods becomes solidified as thin lamellæ, forming in one case in the primary interambulacral spines of the anterior part of the test on the abactinal side, above the ambitus, a spearlike head to the shaft of the radioles; this may have a more or less lobed edge, or if the radiole is curved it forms a somewhat shallow spoon-like extremity with spiny processes; in the shorter radioles of the actinal plastron the lamellæ all develop into this spoon-shaped extremity, which may be perfectly symmetrical, or else developed unequally on one side, according to the position of the radioles on the actinal plastron.

In the earlier stages the fascioles are already covered by the same kind of pavement which we find in the adult, made up of short-stemmed, club-shaped spines closely packed together. There were in some of the larger specimens a few large, short-stemmed, globular pedicellariæ, irregularly scattered over the abactinal surface of the test.

Rhinobrissus micrasteroides A. Ag.

Rhinobrissus micrasteroides A. Ag. Bull. M. C. Z., V., No. 9, p. 192, 1878.
Off Havana, 175 fathoms.
Station 321, Lat. 32° 43′ 25″ N., Long. 77° 20′ 20″ W. 233 fathoms.

Pl. XXIII. Figs. 1–4; Pl. XXVI. Fig. 4.

It is with considerable hesitation that this species is retained in the genus Rhinobrissus, the only specimen obtained by the Blake being a somewhat damaged young stage. From what is known of the modification of the Spatangoids due to growth, there are no characters in this single specimen which are not probably merely modifications due to age. The ambulacra are all flush with the test, and remind us of the earliest

Spatangoids in the geological series. The thin, narrow, ill-defined peripetalous fasciole crosses the petals without affecting their structure, as it does in all the recent Spatangoids. The ambulacra are not petaloid, the ambulacral plates are large, the pairs of pores are distant, and extend nearly to the ambitus. *Homolampas fulva* A. Ag., among the Challenger Echini, has similar embryonic lateral ambulacra, with large plates, and flush with the test, Gualteria alone among the fossils representing a similar stage of this structure in Rhinobrissus.

The indefinite peripetalous fasciole existing with a well defined broad and prominent subanal fasciole indicates that in Spatangoids the fascioles either may have become developed from the peripetalous fasciole, first making its appearance in such genera as Hemiaster, in which, however, the subanal, lateral, and anal fascioles are wanting; or may have developed mainly from the subanal fasciole in such genera as Micraster; Rhinobrissus in the stage here figured (Pl. XXIII. Figs. 3, 4) representing a Micraster stage to which has been added an indistinct peripetalous fasciole, while Periaster would represent the Hemiaster stage with rudimentary subanal and anal fascioles. Another species of the genus collected by the Challenger represents a later stage of development, with sunken lateral ambulacra, a peripetalous, an anal, and a subanal fasciole indicating affinities with the more specialized recent Schizasteridæ.

In a fragment of the upper part of the test, which undoubtedly belonged to a specimen of this species measuring at least 30 mm. in length, the lateral ambulacra were as yet scarcely sunken, and almost flush with the test, the anterior ambulacrum, however, towards the ambitus, being indented and sunken, much as in the genus Homolampas. This fragment is interesting, as it shows that the peripetalous fasciole is not continuous, disappearing in the anterior interambulacral areas before it reaches the odd ambulacrum. The subanal fasciole, judging from a fragment of that part of the test, must have been remarkably prominent.

It is possible that a young Spatangoid which I figured in the Revision of the Echini (Pl. XIV. Fig. 11) may turn out to be the young of this species of Rhinobrissus. It has, like this species, a peripetalous fasciole crossing the petals without modifying their structure; and large ambulacral plates. It differs from it, however, in having a continuous lateral fasciole passing under the anal system, as in Agassizia.

This species of Rhinobrissus (*R. micrasteroides*) will probably form the basis

of a subgenus of Rhinobrissus, which will hold to it very much the same relation which Periaster holds to the true Schizaster. It will represent the embryonic stage of Rhinobrissus and recall to us the earliest true Spatangoid genera of the Chalk still having ambulacra nearly flush with the test, with a well-developed subanal and a rudimentary peripetalous fasciole.

Brissopsis lyrifera Agass.

Lesser Antilles, off Havana. Lat. 28° 51′ 30″ N., Long. 89° 1′ 30″ W. Off the mouth of the Mississippi. Lat. 41° 29′ 45″ N., Long. 65° 47′ 10″ W. 118–1394 fathoms.
For list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 83, 1880.

Pl. XXVI. Figs. 7–18.

Brissopsis lyrifera appears to be one of the most widely distributed species of the Atlantic fauna, and is also found in the Caribbean and in the Gulf of Mexico.

I have already, in the Revision of the Echini (p. 354), spoken of the great variation I had observed in the course of the petaloid ambulacra of this species, as well as of the variations found in the subanal fasciole. An extensive series of specimens of this species has now been brought together by the dredging of the Blake. These throw additional light on the changes we may expect to find among Spatangoids of this group in one and the same species. I had already observed considerable difference in the outline of the test. Specimens dredged off the mouth of the Mississippi were generally quite globular, and presented the extreme form in that direction, while the specimens collected along the east coast of the United States as far north as George's Bank, and in the Eastern Caribbean and the Straits of Florida, although varying considerably in outline, yet presented no very marked differences except such as we have seen were due to growth, and agreed on the whole quite well with the specimens of Brissopsis known from other parts of the North and South Atlantic. Between Jamaica and San Domingo there were dredged three specimens of Brissopsis representing the extreme elongated form, with an anteriorly bevelled flat surface, at the abactinal extremity of which is situated the anal system. These specimens were further characterized by an exceedingly well defined subanal fasciole, with an indistinct anal fasciole extending to the posterior part of the peripetalous fasciole. As mentioned in the Revision of the Echini, the subanal fasciole is quite variable; in many cases the anal

branch is clear and well marked, in others it becomes gradually reduced and indistinct, or finally disappears entirely. The subanal fasciole also appears in the American specimens to be subject to great variations. In the globular specimens from off the mouth of the Mississippi, the subanal fasciole was in some cases well defined, in others somewhat indistinct; in others again only very indistinct and disconnected parts could be traced; and finally in others it had disappeared entirely, as is the case in the genus Toxobrissus, which differs from Brissopsis only in having no subanal fasciole and confluent lateral ambulacra, characters which are here distinctly shown to occur in this species of Brissopsis in specimens found in different localities. The specimens with globular test have retained that embryonic feature alone, while the petals and fascioles have developed in what we might call the normal manner. The excessively elongate and flattened forms found off Jamaica retain of the embryological characters the confluent ambulacra and the position of the anal system on the anteriorly sloped surface, a feature recalling the time when the anal system was distinctly placed on the abactinal surface of the test, and not on the vertically truncated posterior extremity as is usually the case.

In Brissopsis, as in Macropneustes and other Spatangoids, the centralization of the tubercles on certain parts of the plates shows how closely this is connected, on the one hand, with the formation of V-shaped fascioles in the interambulacral and ambulacral areas, as in Macropneustes. In the interambulacral areas the absence of tubercles leaves bare the median and horizontal sutural lines, the median spaces and adjoining angular connections being broader than the horizontal lines. The anterior ambulacra are bare from the extremity of the petals, while in the posterior ambulacra the anterior row of ambulacral plates alone is bare, the posterior row being closely crowded with miliaries. The flat surface enclosed within the branch of the anal fasciole is bare in the central region, somewhat coarsely tuberculated at first towards the exterior; gradually the tuberculation becomes smaller, until it passes into the fine miliaries which form the anal branch of the fasciole, extending from the subanal to the peripetalous fasciole along the central line of the posterior row of ambulacral plates.

Agassizia excentrica A. Ag.

Florida, Cuba, Lesser Antilles. 86–391 fathoms.
For list of Stations, see Bull. M. C. Z., V., No. 9, p. 193, 1878; VIII., No. 2, p. 63, 1880.

Pl. XXV.

When alive the test is covered with spines of a delicate pinkish gray color, darkest at the base. The ambulacral areas are covered with slender, long-stemmed, small-headed pedicellariæ, articulated at the base, while in the interambulacral system the miliaries carry slender, straight, or slightly curved club-shaped spines, scarcely stouter than the stems of the pedicellariæ. The fascioles are still more thickly crowded with similar minute pedicellariæ and club-shaped miliary spines, but somewhat shorter, and closely dotted with large pigment spots.

The actinostome of the genus is marked for the irregular arrangement of the buccal plates. The anal plates are few in number, often less than eight, comparatively large, and form in the young stages a regular anal pyramid, as characteristic as that figured by Gray, Lovén, and myself in Palæostoma.

A few of the tentacles of the odd anterior ambulacrum, near the apical system, are fimbriated like those surrounding the buccal system; those immediately following towards the ambitus are simple, with a slight sucking disk like the tentacles of the anterior rows of pores of the lateral petaloid ambulacra. Within the petaloid area the tentacles of the posterior rows are broader, compressed, irregularly lobed at the extremity; the tentacles beyond become, as in the anterior rows, simple towards the ambitus, and remain so till they join the large fimbriated tentacles surrounding the buccal system. The presence of large fimbriated tentacles near the apical system in the odd ambulacral petal shows that Agassizia is itself an embryonic genus. Other features of the same character are the general globular form, and the rudimentary structure of the lateral anterior ambulacra; the anterior rows of pores of the posterior lateral ambulacra appear only after the posterior rows are well developed.

In a specimen measuring 3 mm. in length, the first ambulacral tentacles to appear are those surrounding the actinostome, which were nine in number and already fimbriated. In the denuded test of a specimen of about the same size, no trace of the subdivision of the test into coronal plates could be detected; it consisted entirely of a close network of fine granulation.

The position of the ambulacral and interambulacral areas was indicated by the presence of rows, more or less irregular, of rudimentary, primary, and secondary tubercles; those of the actinal plastron and of the interambulacral areas being generally more closely defined than those of the ambulacral areas. In this stage the actinostome is pentagonal, with rounded corners, the posterior lip being but slightly indicated.

In a specimen measuring 6 mm. in longitudinal diameter, the posterior lip is quite pronounced, and the actinostome has become transversely elliptical, but the number of buccal tentacles has as yet not increased. The granulation covering the test of the youngest stage examined (3 mm. long) is arranged in short parallel lines forming irregular lozenges, perhaps like those figured by Lovén in the actinal system of several other Echini;* but the boundaries of these figures, if they have any regularity, could not be traced. This stage of the test of Agassizia, covered as it is by a fine granulation such as we find characteristic of the granulation of the fascioles in some of the Spatangoid genera, naturally suggests the idea that the fascioles are merely bands formed by the remnants of the embryonic granulation of the test on which tubercles proper have not yet developed. This rudimentary granulation, arranged in more or less regular lozenge-shaped figures, is a very general structural feature of the coronal plates of many Echini, in which we can trace it readily in the younger stages. See especially Salenia and young Echinidæ and Cidaridæ, as well as other Spatangoids. It is also found in the structure of the plates of the calyx of many Crinoids, and of some plates among the Starfishes, and we are justified in regarding this granulation as the typical structural ornamentation of Echinoderms, which has become specialized in recent times to form among the Spatangoids the so-called fascioles. This would explain the presence of detached bands of fascioles parallel to the principal ones, such as we find in Maretia, Homolampas, Paleopneustes, Macropneustes, and Brissopsis.

If this view of the nature of fascioles is correct, we should be justified in considering the papillæ of the Cidaridæ arranged regularly round the primary spines of the interambulacral areas, as well as the ambulacral papillæ, as modified fascioles not occupying special limited areas. The same would be true of the papillæ of the Saleniæ. A similar explanation would hold good for the down-like spines covering the greater part of the test of Aspidodiadema, and the long hair-like spines of Echinothrix, Centrostepha-

* Lovén, *Études sur les Échinoïdées*, Pls. XIX., XXI.

nus, Astropyga, and other Diadematidæ and Echinothuriæ; in the last, there is, as I have shown, even what we might consider in some cases a regular marginal fasciole, as in Phormosoma. The miliary granulation of the Clypeastroids generally, and the comparatively small radioles they carry, may according to this view be considered as embryonic features which have become greatly specialized, the whole test retaining the granular tuberculation characteristic of the earlier Crinoids, with but slight modifications in the fasciolar radioles covering the whole test, if I may so call them, while they become, strictly speaking, minute primary or secondary radioles.

Although in the young stages of such Spatangoids as Hemiaster, Brissopsis, Schizaster, and the like, the fascioles make their appearance very early, yet in this youngest stage of Agassizia there is at a corresponding period no well-defined fasciole band, and it is only in a somewhat more advanced stage (4 mm. long. diam.) that we get a clearly defined fasciole. This seems to affect the character of the spines found above and below it, and we have in the stage just mentioned a well-defined lateral marginal fasciole close to the ambitus. This fasciole is in reality only an extension of the subanal fasciole, such as we find a remnant of in Argopatagus. The peripetalous fasciole is also developed, and its anterior extremity comes down close to the ambitus, as it does in Paleopneustes.

In the youngest Agassizia (3 mm. long. diam.) there are three or four single pores forming the rudimentary petals of the lateral ambulacra. The apical system is represented in this stage merely by the large madreporic body which covers the whole apex. The surface of the test in these younger stages, more especially in the ambulacral areas, is covered by numerous small-headed, short-stemmed pedicellariæ and by minute straight miliary spines, often club-shaped.

In a specimen measuring 6 mm. in longitudinal diameter, the odd anterior ambulacrum was not yet developed at all; the lateral ambulacra consisted of six and seven pores, the anterior ambulacra being composed of single rows of pores, the posterior ambulacra of double rows; the anterior rows of the posterior ambulacra were made up of three small pairs of pores with a couple of single pores near the apex of the ambulacrum.

Meoma ventricosa Lütk.

Florida Bank, and off Havana. 37–127 fathoms.

Schizaster fragilis Agass.

Quite a common species near the 100 fathom line, off the New England coast. 71–362 fathoms. For a list of Stations, see Bull. M. C. Z., VIII., No. 2, p. 84, 1880.

Pl. XXVIII. Figs. 8–14.

There is considerable variation in the distinctness of the lateral fasciole as it passes under the anal system. In some cases it stops suddenly near the level of the anal system; in others it can be faintly traced as an indistinct, irregular anal fasciole; in others the anal fasciole is most clearly marked. These differences do not depend on size, but specimens from one locality are usually similarly affected. Small specimens measuring 6 mm. in longitudinal diameter are but slightly elliptical when seen from above, the anterior ambulacrum scarcely indented, and the lateral ambulacra still flush with the test. The actinal side is slightly convex, the outline seen in profile is hemispherical, the apex being nearly central; the circular anal system, flush with the test, is placed high on the posterior extremity of the test. Both the peripetalous and lateral fascioles are well marked as narrow bands of miliaries, indicating in a very rough way the future indentations of the course of the fascioles. In this stage the posterior ambulacra consist only of two pairs of pores, and are scarcely one quarter the length of the anterior lateral ambulacra. There is no trace as yet of any genital openings. The actinal opening is circular, without a posterior lip, and the posterior edge of the actinostome is placed nearer to the central part of the actinal side than to the anterior edge of the test.

In specimens measuring 10 mm. in length, the posterior lateral ambulacra are still flush with the test, with five pairs of pores; the anterior ambulacra are slightly sunken. The odd ambulacrum is more sunken than in the younger stage described. The madreporic body, which in the preceding stage was only pierced by a single opening, is now marked by five or six small openings. There is as yet no sign of any genital openings. The posterior extremity of the test is more vertically truncated; the anal system is more elliptical, and placed at the upper angle of the posterior level of the test. The fascioles are somewhat broader than in the younger stage; they vary in width, the angles of the ambulacra assuming more clearly already the general course they finally take in larger specimens. The actinal opening is now placed well towards the anterior extremity. The outline of the

test from above is still elliptical, with the exception of the anterior re-entering angle of the odd ambulacrum and of the posterior extremity of the test. The apex is now posterior to the abactinal system, the anterior extremity sloping gradually toward the ambitus, while the posterior extremity of the test extends nearly horizontally to the junction of the vertically truncated posterior extremity.

In specimens measuring 23 mm. in length the outline of the test when seen from above shows traces of the angular projections which characterize the full-grown specimens. The test is slightly pointed posteriorly. The odd ambulacrum is deeply sunken nearly to the apical system, while in the preceding stages the odd ambulacral groove extended only a short distance from the ambitus to the apex. The lateral ambulacra are now all sunken, the posterior ambulacra somewhat less than the anterior pair; these have now eleven pairs of pores. There are three large genital openings, the two left anterior ones and the right posterior one. The fascioles have nearly assumed the course and shape they take in the adult. The posterior extremity is bevelled towards the actinal extremity, so that over the anal system the test projects slightly beyond the general outline. The actinal system is now quite flat, the actinostome has a well-developed posterior lip, of which a trace only can be found in specimens measuring about 10 mm. in length. The tuberculation and the corresponding spines have now assumed the general characteristics of the tuberculation at different parts of the test; while in younger stages the tubercles were few in number, comparatively large, and irregularly arranged over the sides and upper surface of the test. The actinal plastron is the first to appear, and in the youngest specimens examined the tuberculation of that area as well as the spines had already become specialized to a certain extent.

In specimens measuring 34 mm. in length, the test, as seen from above and in profile, has assumed the outline of adult specimens; and we find already in specimens of this size as much variation in the closeness of the tuberculation, the depth of ambulacral furrows, the course and shape of the fascioles, the outline of the test as seen from different points of view, and the specialization of the spines of different parts of the test, as we do in the larger specimens.

* Schizaster orbignyanus A. Ag.

Schizaster orbignyanus A. Ag. Bull. M. C. Z., VIII., No. 2, p. 84, 1880.
Lesser Antilles. 92–1507 fathoms.

Pl. XXVIII. Figs. 1–7.

This species extends as far north as the New England coast, specimens having been dredged by the United States Fish Commission off Martha's Vineyard in 100 and 130 fathoms. They differ very considerably from the specimens dredged by the Blake in the Eastern Caribbean. The northern specimens, while retaining the characteristic outline of those from the Caribbean, yet differ from them in having a much broader peripetalous fasciole, more like that of *S. canaliferus;* the northern and southern specimens, again, agree in the great width of the actinal plastron at the posterior extremity, and the small size of the anal system as compared with that of *S. canaliferus*, and are covered by a closer tuberculation also, a character which readily distinguishes the specimens of the two species thus far compared. The test from the lower side of the anal system to the edge of the actinal plastron is more bevelled than in *S. canaliferus*. In the few specimens of *S. orbignyanus* I have had occasion to examine, the lateral and anal fascioles vary greatly in distinctness. In the Caribbean specimens the lateral fasciole extends continuously along the sides of the test to the level of the side of the anal system, and there forms a sharp, well-defined triangular anal fasciole. In the northern specimens the lateral fasciole is often indistinct or disappears entirely, only the anal fasciole remaining. It is interesting to note that, in the specimens of *S. fragilis* dredged off our eastern coast, the anal fasciole disappears first, leaving only a part of the lateral fasciole extending from the peripetalous fasciole towards the anal system. The peripetalous fascioles are of a dark violet color, forming a strong contrast to the greenish yellow spines with silvery lustre which cover the upper part of the test. The lateral and anal fascioles can scarcely be distinguished by their color from the spines of the actinal side and those towards the ambitus, which with the exception of the spatula-shaped spines of the actinal plastron are of a darker color than those of the abactinal side of the test, and within the peripetalous fasciole.

Whether the differences here noted between *S. canaliferus* and *S. orbignyanus* are merely local or more important, comparisons of more extensive series of these species alone can determine.

* Schizaster (Periaster) limicola A. Ag.

Schizaster (Periaster) limicola Agass. Bull. M. C. Z., V., No. 9, p. 193, Pl. III., 1878.

Pl. XXVI. Figs. 5, 6.

This species belongs to the generic group of Schizaster separated as Periaster by D'Orbigny from the genuine Schizaster. The test is quite globular, when seen from above the outline is somewhat angular, the posterior extremity is vertically truncated, with a slight keel between the posterior petals near the apex; the anterior extremity has a shallow ambulacral groove, and is vertically truncated from the edge of the peripetalous fasciole. The lateral anterior petals are nearly twice as long as the posterior one, as well as broader. The petals are all about equally sunken. The peripetalous fasciole has the shape and position of that of Schizaster proper; the anal fasciole is narrow, extending only a short distance on the sides of the test.

The test is thickly covered with primary tubercles of a uniform size, carrying short, slightly curved spines on the sides; the tubercles are somewhat more crowded within the fasciole and on the abactinal region of the odd posterior interambulacral area. The coronal plates between the fasciole and the anal system are comparatively bare, having only few tubercles on the outer edges. On the actinal side the primary tubercles are larger, more distant, except on the actinal plastron, where they are closely crowded, and carry longer, larger, and curved primary spines. The actinal lip is very sharp and prominent; the actinal membrane carries one large exterior row of plates round the anterior edge of the actinostome, and smaller irregular plates over the rest of the actinal surface. The anal system is comparatively small for so large a species. The separation of this group of Schizaster as a generic type seems very doubtful. It is based solely upon the more globular outline of the test, and the discontinuity of the latero-anal fasciole. It may be convenient to form a subgeneric group with these characters; but when we attempt to draw the line between such forms as *S. ventricosus* and *S. japonicus*, it becomes most difficult, if not impossible, to draw the line of demarkation between the generic and subgeneric types.

We find the same difficulty in attempting to define the numerous generic subdivisions indicated by Troschel for the genus Tripylus and its allied forms, which pass insensibly to Faorina and the like, while in Schizaster the deviations are in the direction of modifications passing into Periaster, Epiaster,

Hemiaster, and the like. The structure of the odd anterior ambulacrum of this species has all the characteristics of the odd ambulacrum of such species of Schizaster proper as *S. canaliferus*, *S. fragilis*, and *S. Philippii*, while it has the outline of the test of Hemiaster and the fascioles of Periaster. There are but two genital openings. When brought up in the dredge, this species was of a dirty yellowish-brown color. This species has an extensive geographical range, having been collected by the Challenger in the Arafura Sea.

The Schizasterids which have been united under the generic name of Periaster are interesting as representing a truly embryonic stage of Schizaster proper. As is well known from the study of the young of several species of Schizaster in the earliest stages of growth, they have a globular test, the ambulacral grooves are either indistinct, or only slightly developed, or totally absent. The peripetalous fasciole is broad, but slightly indented; in fact, all the characteristic features of the genus are those which we find in the young stages of such species of Schizaster as *S. orbignyanus*, *S. fragilis*, and *S. japonicus*. If we were to magnify a young *S. fragilis* measuring about 10 mm. in diameter about six times, we should have a fair representative of the genus Periaster, provided we took into account the great variation of the lateral fasciole, which is more or less indistinct as it passes towards and under the anal system to form the anal fasciole in such species as *S. fragilis* and *S. Moseleyi*. The odd anterior ambulacrum is, like all the other ambulacra, but slightly sunken, and indicated by a broad re-entering angle at the ambitus, neither of the lateral pairs of ambulacra being as deeply sunken as in Schizaster proper, the posterior pair being, as in most of the Schizasteridæ, shorter than the anterior pair. The relative proportions of the lateral ambulacra recall to a certain extent the structure of the ambulacra of the older Spatangoids of the Chalk, such as Hemiaster proper. In large specimens of *Periaster limicola* measuring 68 mm. in length, there are two posterior genital openings, as in Hemiaster, the ocular plates are large, and the madreporic body is elongate, extending longitudinally over the greater part of the apical system.

ORIGIN OF THE WEST INDIAN (CARIBBEAN) ECHINID FAUNA.

The resemblance of the Fauna of the Gulf of Mexico and of the Caribbean to that of the Pacific has been noticed by former writers, even at a time when the materials available for comparison included but little beyond the littoral Fauna. Since the results of the deep-sea dredgings have become known, the extent of this resemblance has become quite striking. In fact, the deep-sea Fauna of the Caribbean and of the Gulf of Mexico is far more closely allied to that of the Pacific than to that of the Atlantic. Before the Cretaceous period, the Gulf of Mexico and the Caribbean were undoubtedly in freer communication with the Pacific than with the Atlantic Ocean; so that, while probably before that time the Fauna of these seas contained a number of Atlantic types, yet the characteristic genera were common to the Pacific. Many of the genera have remained unchanged to the present day since the absolute separation of the Atlantic and of the Pacific by the Isthmus of Panama and the Mexican Plateau, while there have been added to the West Indian Fauna a number of Atlantic types, which, as long as the Gulf of Mexico and the Caribbean were practically a part of the Pacific, probably did not find conditions as suitable to their development as those which now exist, and which have existed since their separation from the time they became merely extensions of the equatorial Atlantic district.

This explanation gives us an apparently good reason for the mixed character of the Fauna of the West Indian seas, showing us at the same time that, however long a period of time may have elapsed since this separation has taken place, it has not been sufficient to effect any very radical change in the Echinid Fauna of the two sides of the Isthmus. The principal differences are due to the immigration of true Atlantic types into the West Indian faunal region during the Tertiary and Post-tertiary period. But as the principal physical conditions of the sea in the tropical regions of the two sides of the Isthmus appear to be so nearly identical, we could not expect any great differences to arise between the Panamic and West Indian Faunæ from physical causes alone.

In order to show the former distribution of the genera of which the Echinid Fauna of the West Indies is made up, we must trace as far as possible the origin of these genera. We find at the outset a few old genera, like Cidaris, Dorocidaris, Porocidaris, and Salenia, dating back to the Jurassic period, and which already in the Tertiary had probably as extensive a geographical distribution as at the present day. Dorocidaris and Porocidaris at the present time are Atlantic and Indo-Pacific genera, while Salenia and Cidaris are confined to the warmer belts of the same oceans.

Hemipedina, which dates back to the Jura, is found fossil in the Tertiary of North America, and has thus far not been dredged outside of the Caribbean Fauna. Pygaster is also a Jurassic genus, but it is most probable that the *Pygaster relictus* is only the young of one of the West Indian Spatangoids with an ancient facies, as has been suggested by De Loriol. The genera which date back to the Cretaceous period, either actually or by closely allied genera, are Podocidaris, Asthenosoma, Phormosoma, Temnechinus, Echinus, Echinocyamus, Conoclypus, Rhynchopygus, Pourtalesia, Hemiaster, and Periaster.

Of these genera, Temnechinus, Echinus, Hemiaster, and Periaster already had during the Tertiary as extensive a geographical range as to-day. At the present time, Echinus extends over the Atlantic, the Indian, and the Pacific Oceans; Temnechinus is a tropical Atlantic and Pacific genus; Hemiaster is characteristic of the Atlantic and of the North Pacific, Periaster of the East American tropical Atlantic and tropical Pacific, and Rhynchopygus appears limited to-day to the American faunal districts of the same oceans, although it has been found in the Tertiaries of Australia and of Europe. Nothing is known of the distribution during the Tertiary of the Atlantic and Pacific genera Pourtalesia, Asthenosoma, and Phormosoma. Podocidaris is a tropical Atlantic and Pacific genus. Echinocyamus extends in the North Atlantic to within the tropics.

The genera dating back to the earlier Tertiary period include by far the greater number of the genera of the West Indian Fauna; they are Cœlopleurus, Strongylocentrotus, Trigonocidaris, Toxopneustes, Hipponoë, Clypeaster, Echinanthus, Echinonëus, Neolampas, Echinolampas, Homolampas, Palæopneustes, Linopneustes, Spatangus, Echinocardium, Rhinobrissus, Brissopsis, Agassizia, Brissus, Metalia, Meoma, Macropneustes, Schizaster, and Moira. Of these the genera extending in the equatorial belt of the Atlantic and Indo-Pacific region are Trigonocidaris, Toxopneustes, Hipponoë, Clype-

aster, Echinanthus, Echinolampas, Homolampas, Paleopneustes, Linopneustes, Rhinobrissus, Brissus, and Metalia. The genera having an Atlantic and Pacific range are Strongylocentrotus, Spatangus, Echinocardium, Brissopsis, and Schizaster. Leaving only with a more or less limited range Cœlopleurus, found in the Caribbean, Indian Ocean, and East Indian Archipelago, and with nearly the same distribution in the Tertiary, having only disappeared from the Eastern North Atlantic region where it once flourished. Echinonëus, Cœlopleurus, and Macropneustes have very much the same geographical and geological range. Agassizia, Meoma, and Moira are probably strictly tropical American genera, occurring both on the Pacific and Atlantic sides of the continent; but they formerly had a much wider geographical distribution, Agassizia having been found in the Tertiary of Egypt and Meoma in Australia.

The genera dating back only to the later Tertiary period are Arbacia, Echinometra, Mellita, and Encope. But little is known of their former geographical extension. Echinometra is a tropical Atlantic and Indo-Pacific genus; Arbacia is a tropical Atlantic and Pacific genus, most widely distributed on both sides of the American continent; while Mellita* and Encope are eminently tropical American, occurring on both sides of the continent.

This leaves the genera Diadema, Aspidodiadema, Palæotropus, Palæobrissus, Urechinus, Cystechinus, and Aceste, which have as yet not been found fossil. These genera, with the exception of Cystechinus, limited to the Southern Atlantic and Pacific, and Palæobrissus, which represents Platybrissus in the Atlantic, have an extended geographical range in the tropical belt of both the Atlantic and the Pacific Oceans. The nearest allies of Diadema and of Aspidodiadema date back to the Cretaceous, and Palæotropus, Palæobrissus, Urechinus, and Cystechinus are to-day the old-fashioned representatives of the types of Spatangoids which characterized the Cretaceous seas.

This analysis shows that the Echinid Fauna of the West Indian seas of to-day is made up (1.) of five genera which date back to the Jurassic period; (2.) of ten genera which go back to the Cretaceous period; (3.) of twenty-four genera dating from the earlier Tertiary period; (4.) of only four genera characteristic of the later Tertiaries; (5.) of seven genera which we may look upon as the representatives of the Ananchytidæ and Infulasteridæ, and of the Pseudodiadematidæ of the Cretaceous period. In all these old-fashioned genera we find species having a cosmopolitan range.

* One species of Mellita is said to come from the Red Sea.

Of the so-called American genera, all containing most closely allied representative species, Agassizia, Moira, Meoma, Macropneustes, Arbacia, Encope, and Mellita, which probably flourished in the central American seas soon after the closing of the Isthmus of Panama, the three Spatangoids date back to the Cretaceous, the two Clypeastroids and two Echinidæ to the later Tertiary. We find the nearest allies of the Clypeastroids in the Tertiaries of Western France and of Egypt; the above-named West Indian Spatangoids and Clypeastroids, as well as Cœlopleurus and Macropneustes, first disappeared from the Eastern Atlantic. The past history of the ten West Indian genera already found in the Cretaceous, and of the twenty-four genera descending from the earlier Tertiary, gives us but little assistance in determining their probable mode of appearance in the Caribbean Fauna.

As far as we can now judge, the separation of the Caribbean and the Gulf of Mexico from the Pacific was brought about by the formation of the Florida and Yucatan Banks by their elevation above the level of the sea, in addition to the raising of the Greater and Lesser Antilles, of the Plateau of Mexico, and of the whole of Central America, ending in the complete closing of all connection at the Isthmus of Panama. These elevations have been gradually taking place from the close of the Cretaceous period to the most recent Post-tertiary times, and to the successive changes they have brought about in the physical conditions of the Gulf of Mexico and of the Caribbean Sea we must ascribe in the main the existing state of the West Indian Echinid Fauna as compared with the Echinid Fauna of other geographical districts.

It would be most interesting to be able to make a comparison of the deep-sea Panamic Fauna with that of the Caribbean, and ascertain if in the continental and abyssal regions, at the depths beyond which the effects of light and of heat are not prominent factors, we find as marked a difference in the representative species as in those of the littoral Fauna.

The West Indian Echinid Fauna comprises more than a quarter of all the known species of Echini, and if we take what we might call the tropical Atlantic Fauna it includes a little over one third of all the known species. The known species of the Indo-Pacific realm, which we might call the tropical Indo-Pacific Fauna, are somewhat more numerous; so that we have more than two thirds of all the known species of Echini belonging to this great tropical oceanic belt, the northern and southern limits of which extend somewhat into the temperate regions. This leaves less than one third of the known Echini as representatives of the other faunal districts. There are

only at present thirty-four genera characteristic of the Indo-Pacific not found in the Atlantic, and only eight genera characteristic of the Atlantic not as yet discovered in the Pacific,* while the Atlantic and Pacific have thirty-six genera in common. Of the genera they have in common, four date back to the Jura, seven to the Cretaceous, sixteen to the Tertiary; the others belong to the Diadematidæ, which have their nearest allies in the Cretaceous, as well as the five recent genera of Ananchytidæ and Pourtalesiæ.

Of the genera special to the Indo-Pacific, two date back to the Jura, as many to the Cretaceous, twenty-one to the Tertiary; there are left the genera of Diadematidæ, of Ananchytidæ, and of Pourtalesiæ, derived from the Cretaceous. The Echinometradæ genera of the Pacific have no fossil representatives. Of the special Atlantic genera, two are Jurassic, two Cretaceous, one Tertiary; the other has no fossil representative.

Soon after the end of the Cretaceous period the specialization of the great Atlantic and Indo-Pacific marine realms began. Before that time the equatorial currents probably swept nearly uninterruptedly round the globe, and maintained across the Indo-Pacific and Atlantic nearly the conditions existing in the Western Atlantic before the equatorial currents became deflected by the West India Islands and the northern extremity of South America. If the physical causes we now see at work have, as they became changed, also modified the Fauna of the then existing equatorial belt district, we should naturally expect to notice after a long period of time the changes they brought about. We are probably justified in ascribing to the subdivision of this great equatorial belt into an Indo-Pacific and an Atlantic district the marked changes we can trace in the character of the Fauna as affecting the genera which date back to the late Cretaceous, and which become still more marked if we trace them in the genera dating back to the Tertiary period.

How far it is possible for us directly to follow the changes which have taken place, and to trace the gradual passage of the older Fauna into the characteristic West Indian Fauna of to-day, is another question. This involves the necessity of tracing back from the Triassic and Jurassic periods the genera which have appeared in succession, and how far this is practicable I have attempted to show on a former occasion.† I would also

* We should also bear in mind that, of the eight genera characteristic of the Atlantic alone, we find closely allied representative genera in the Indo-Pacific realm.

† Palæontological and Embryological Development, Address at the Boston Meeting for 1880 of the American Association for the Advancement of Science.

refer for details to the List I have given in the Challenger Report * of known species of Echini, where the bathymetrical, geographical, and geological range is given as far as known at that time. To this List should be added the deep-sea species collected by the "Gazelle" and described by Studer, and the necessary additions and modifications which are suggested in this Report.

The following Table, containing a complete list of all the West Indian species of Echini, extended so as to include the few species which thus far have not yet been found in the West Indian district, has been prepared, for the sake of comparing the West Indian species with the Panamic Echini, and with the representative species of Echini found in the American deposits of the Post-Pliocene, Miocene, Eocene, Cretaceous, and Jurassic periods. In the column of the principal localities, the present and past geographical and geological extension of the genus is given, to allow a ready comparison of the actual and former distribution of the present West Indian genera to be made. The geographical range of each species is also given. When several representative species have been described, they have all been enumerated.

* Report on the Echinoidea: Report on the Scientific Results of the Voyage of H. M. S. Challenger, Pt. IX., p. 208, 1881.

[illegible] West Indies Fossil	Principal Localities and Geological Range of Genera	Fossil Species	Pacific Species	Pliocene	Miocene	Eocene	Cretaceous
Desmosticha Haeckel							
Cidaridæ Mill.							
Gomocidaridæ Haeckel.							
Cidaris Kl.	[illegible] Atlantic, Indo-Pacific. — Pliocene, Miocene, Eocene, [illegible], Antarctic, Malta, India, Australia), Upper and Lower Chalk, Jura, Lias, [illegible]						
C. trituloides Bl.	S. Carolina, Brazil, Cape Palmas.	C. Thouarsii Val.	.....	.....	C. Anguillæ Cott. Anguilla.	C. Alabamensis Mort., Ala. C. Mortoni Con. Georgia.	C. hemigranosus Shum., La. Pseudocidaris, Mexico.
Dorocidaris A. Ag.	[illegible], Indo-Pacific, Tertiary (N. Am., Austria), Chalk, Jura.						
D. Bartletti A. Ag.	West Indies.						
D. Blakei A. Ag.	" "						
D. papillata A. Ag.	[illegible], Mediterranean, Canaries, West Indies, St. Paul Rocks, La Plata, Philippines.	[illegible]	[illegible]	[illegible]	[illegible] Anguilla.	[illegible] St. Bart.	[illegible] Mort., N. J.
Porocidaris Des.	Tropical and Temperate Atlantic and Pacific. — Miocene, Eocene (France, Egypt, India, Num.), Jura.						
P. Shafferi A. Ag.	West Indies.						
Salenidæ Ver.							
Salema Gray	Atlantic, Tropical Pacific. — Miocene, Eocene (France, Australia), Upper and Lower [illegible], England, Germany), Upper Jura.						
S. goesiana Lov.	West Indies.						
S. Pattersoni A. Ag.	" "						
S. variispina A. Ag.	[illegible], Brazil, Antarctic, [illegible]						
Arbaciadæ Gray							
Arbacia Gray	[illegible], Pacific, Lower Tertiary, N. Am.						
A. punctulata Gray	Long Island Sound to Yucatan.	A. stellata Gray	A. punctulata Hupé. S. Cayenne.	Arbacia sp. Mich. S. Carolina.			
A. pustulosa Gray	Mediterranean, Libyan, Brazil.						
Podocidaris A. Ag.	Upper Cretaceous, [illegible], [illegible]						

West Indian Echini.	Principal Localities and Geological Range of Genus.	Pliocene Echini.	Post Pliocene.	Pliocene.	Miocene.	Eocene.	Cretaceous.
P. sculpta A. Ag.	West Indies.						
P. scutata A. Ag.	" "						
Cœlopleurus Agass.	Tropical Atlantic, Indo-Pacific. — Eocene, Crag (England), Num. (India), North America, France, Italy.						
C. floridanus A. Ag.	West Indies.					C. infulatus Des. Santee, S. C.	
Diadematidæ Peters.							
Diadema Schynv.	Tropical Atlantic, Indo-Pacific.						Pseudodiadema diatremum Des. N. J.
D. setosum Gray	West Indies, Bermudas, Cape Verde Islands, Indian Ocean, Japan, Sandwich Islands, Fiji Islands.	D. mexicanum A. Ag. Astropyga pulvinata Agass.					Phymosoma texanum Röm. Diadematexanum Shum., Texas.
Aspidodiadema A. Ag.	Tropical Atlantic and Pacific. — Miocene, Jura (Polycidaris Quenst.)						
A. microtuberculatum A. Ag.	Macio, Tristan d' Acunha, No. Brazil, Chili.				Cid. Clevei Cott. Anguilla.		
A. antillarum A. Ag.	West Indies.						
A. Jacobyi A. Ag.	" "						
Echinothuridæ Wyv. Thom.	Chalk (Echinothuria)						
Asthenosoma Grube	Atlantic, Tropical Pacific.						
A. hystrix A. Ag.	Rockall, Cape Finisterre, West Indies.						
Phormosoma Wyv. Thom.	Atlantic, Pacific.						
P. placenta Wyv. Thom.	West Indies, Atlantic Coast, Southern and Middle States of U. S., West Coast of Scotland and Ireland.						
P. uranus Wyv. Thom.	West Indies, Atlantic Coast, Southern and Middle States of U. S., West Coast of Scotland and Ireland, and Eastern Atlantic.						
Echinometradæ Gray							
Echinometra Rond. (Breyn)	Tropical Atlantic, Indo-Pacific. — Miocene, N. A.						
E. subangularis Desml.	Senegal, Ascension, Bermudas, West Indies, Brazil.	E. Van Brunti A. Ag.					

[illegible] West Indian Species	Recent; [illegible] Miocene, Eocene.	Pliocene Fossil	Post Pliocene	Drift	Museums	Localities	Remarks
E. viridis A. Ag.	West Indies.	.....	.....	.....	E. [illegible] Cott. Anguilla.		
Strongylocentrotus Br.	Atlantic, Pacific. — Pliocene, Miocene: N. Am., Sweden Java.						
S. Drôbachiensis A. Ag.	[illegible], N. E. Coast of N. Am., No. Pacific.	S. [illegible] A. Ag.	S. D[illegible] A. Ag., Drift				
S. Gaimardi A. Ag.	Brazil.						
S. lividus Br.	Europ. Atlantic, Mediterranean, Azores, Brazil.						
Echinidæ Agass.							
Temnopleuridæ Des.							
Temnechinus Forbes	Tropical Atlantic. — Crag; Tertiary (Australia, India); Cre[illegible]						
T. maculatus A. Ag.	Azores, West Indies.						
Trigonocidaris A. Ag.	Tropical Atlantic and Pacific. — Tertiary, Australia (Pawday [illegible])						
T. albida A. Ag.	Josephine Bank, West Indies.						
Triplechinidæ A. Ag.							
Hemipedina Wright	Tropical West Atlantic.—Lower [illegible]						
H. cubensis A. Ag.	[illegible]						cubensis Cott. Cuba.
Echinus Rond. (Lin.)	Atlantic, Indo-Pacific. — Plio[illegible], Miocene, Eocene, (Crag) England, France, Miller Academy, N. Am., [illegible] Cretaceous.						
E. acutus Lamk.	[illegible], Mediterranean, Ascension, Halifax to New York, [illegible]						
E. elegans Düb. o. Kor.	Norway, Mediterranean, Halifax to New York. — Tristan d'Acunha, Papua.						
E. esculentus Lin.	[illegible], Ireland, England, Channel.						
E. gracilis A. Ag.	West Indies.				E. [illegible]		
E. norvegicus Düb. o. Kor.	Norway, Mediterranean, Atlantic Coast of U. S., West Indies, West Patagonia, Japan.	....		[illegible] M[illegible]	Con., Va. E. [illegible] Con., Va.		

[illegible]	Principal Localities and Geological Range of Genus.	Pliocene Echini	Post-Pliocene	Pliocene	Miocene	Eocene	Cretaceous
E. Wallisi A. Ag.	East Coast Atlantic States (South America to Southern New England), Norway.						
Toxopneustes Agass.	Tropical Atlantic, Indo-Pacific.						
T. variegatus A. Ag.	Bermudas, S. C., West Indies, Brazil.	T. semituberculatus A. Ag. T. pileolus Agass.	Ech. variegatus Holmes, S. C.				
Hipponoë Gray.	Tropical Atlantic, Indo-Pacific. — Miocene, France.						
H. esculenta A. Ag.	Bermudas, Florida, Surinam, Brazil.	H. depressa A. Ag.					
Clypeastridæ Agass.						Discoidea Haldemani Con., Ga. Galeraites Agassizii Morr. Ala.	Pavina Pauvi Hall, Texas. Holectypus planatus Rolm. Texas.
Echinoconidæ D'Orb.					Echinoconus Lanieri D'Orb. Guadeloupe.	E. Lanieri D'Orb. E. antillensis Cott., Cuba.	
Pygaster Agass.	Tropical West Atlantic. — Cretaceous, Jurassic.						
P. relictus Lov.	West Indies.						
Enclypeastridæ Haeckel.							
Fibularina Gray.					Sismondia Anguillæ Cott. Anguilla.	Sismondia marginalis Con. S. C. S. crustuloides Des., S. C. S. alta Cott. St. Bart. S. antillarum Cott., St. Bart.	
Echinocyamus Van Phels.	North Atlantic. — Miocene, Switzerland, France, Austria; Upper Chalk, France, Belgium, Sicily.						
E. pusillus Gray	Norway, Ireland, Mediterranean, Azores, West Indies, Brazil.						
Clypeaster Lamk.	Tropical Atlantic, Indo-Pacific. — Pliocene, Miocene, Eocene; N. Am., Italy, Corsica, Java.					Mortoni Rogersii Des., Ala.	
C. latissimus A. Ag.	West Indies, N. Brazil.						

[illegible] West Indian Echini	Principal Localities and Geological Range of Genus	Pliocene Species	Post-Pliocene	Pliocene	Miocene	Eocene	Cretaceous.
C. Ravenellii A. Ag.	S. C., West Indies.	C. serratus A. Ag.				C. Jamesii Des. Ca.	
C. subdepressus Agass.	West Africa, S. C., Brazil.				C. Mississippiensis Mort., Gmelin		
Echinanthus Brevs	Tropical Atlantic and Pacific. Pliocene, Miocene, Eocene, Antilles, Cuba, Mexico, India, Java, Australia.						
E. rosaceus Gray	S. C., West Indies.	.....	.....	C. incurvatus Desm., Guad. C. parvus Duch. Guadeloupe.	C. cubensis Cott. Cuba. C. antillarum Cott. C. concavus Cott. Antilles.		
Scutellidæ Agass.							
Echinarachnius Leske	Arctic, Indian, Pacific. Tertiary N. Am., Patagonia, Australia.			Scutella Martinii Duch., Guad.		Scutella Leskii Des., S. C.	Peltastes ellipticus Ag., Del.
E. parma Gray.	Labrador to New York, Vancouver, Japan, Australia, Red Sea, India.	E. granulata Val.					
Mellita Kl.	American Tropical Atlantic and Pacific. — Pliocene, N. A.						
M. sexforis A. Ag.	S. C. to Brazil.	M. pentaphora Verr.	M. keystonensis McCr., S. C.				
M. testudinata Kl.	Nantucket to Brazil.	M. longifissa Mich.	M. Bigbyi Holmes, S. C. M. keystonensis S. C.	M. ampla Desor, Guad. M. carolinianna Ray., S. C. M. texana, Con. Texas			
Encope Agass.	Antilles, Tropical Atlantic and Pacific. — N. A. Pliocene, Miocene.						
E. emarginata Agass.	S. C. to Brazil.	E. californica Verr. E. micropora Ag.					
E. Michelini Agass.	West Indies.	E. grandis Ag.		Encope phora Lütk. S. C.	E. [illegible]phora Lütk., S. C. Encope Ciæ Dec., Cuba.		
Petalosticha Haeckel							
Cassidulidæ Agass.							

(Caribbean) West Indian Echini.	Principal Localities and Geological Range of Genus.	Panamic Echini.	Post-Pliocene.	Pliocene.	Miocene.	Eocene.	Cretaceous.
Echinoneidæ Agass.							
Echinonëus Van Phels.	Tropical Atlantic, Indo-Pacific. — Pliocene, Miocene ; N. Am., West Indies.						
E. semilunaris Lamk.	West Indies.			E. semilunaris, Guad., Cuba. E. cyclostomus D'Orb. non Auct., Guad.	E. semilunaris, Anguilla.		
Nucleolidæ Agass.						Amblypygus americanus Mich., Jam.	
Neolampas A. Ag.	Tropical Atlantic.					Catopygus Conradi Cp., Ga.	Catopygus oviformis C., N. J.
N. rostellata A. Ag.	West Indies, N. E. Atlantic.						Faujasia florealis D'Orb., Del.
Echinolampas Gray.	Tropical Atlantic, Indo-Pacific. — Tertiary : European, India, Java, Australia, West Indies, N. Am.						
E. depressa Gray.	West Indies.				E. lycopersicus Guppy. E. anguillæ Cott. Anguilla.	E. antillarum Cott. E. ovumserpentis Guppy. E. Clevei Cott. St. Bart. E. Castroi Cott. Cuba.	
Conolampas A. Ag.	Tropical West Atlantic. — Miocene, Eocene, Europe, Crimea, West Indies (Phyllobrissus) ; Upper Chalk.						
C. Sigsbei A. Ag.	West Indies.					Echinol. seniorbis Guppy. St. Bart.	
Rhynchopygus D'Orb.	Tropical American Atlantic and Pacific. — Tertiary, Europe, Australia, West Indies ; Gault, India.						
R. caribæarum Lütk.	West Indies.	R. pacificus A. Ag.		R. guadeloupensis Duch. Guad.	Cassidulus abruptus C. Casubquadratus C. Cass. sp., Miss.	Echinanth. Mortonis Des. Miss. E. antillarum Cott., St. Bart.	Trematopygus crucifer Des. N. J. Cassidulus aequoreus M., N. J.

(Caribbean) West Indian Echini	Principal Localities and Geological Range of Genus.	Pliocene. Eocene.	Post Pliocene.	Pliocene.	Miocene.	Eocene.	Cretaceous.
R. caribbearum L. ex Desmoulins	West Indies.	..		...	...	Pygorhynchus crucifer RAV. P. rugosus RAV. Eocene, S. C. P. Gouldii DES., Ga. P. [illegible] Miss., Ala.	[illegible] mis DES., Ga. C. micrococcus GABB., Ala.
Spatangidæ AGASS.							
Pourtalesiæ A. AG.							
Pourtalesia A. AG.	Atlantic, Pacific. — Crag (Echinarachnius Woodi).						
P miranda A. AG.	Shetland Islands, West Indies, off Martha's Vineyard, U. S. Fish Com.						
P. phiale WYV. THOM.	Kerguelen, Australia, N. C.						
P. Jeffreysi WYV. THOM.	Faroe to Shetland Isl., off Martha's Vineyard, U. S. Fish Com.						
Spatagocystis A. AG.	So. Pacific, Caribbean.						
S. sp. A. AG.	West Indies.						
Urechinus A. AG.	South Atlantic and Pacific.						
U. naresianus A. AG.	Antarctic to Australia, Japan [illegible] according to Clark. West Indies.						
Cystechinus A. AG.	South Pacific and Atlantic.						
C. clypeatus A. AG.	Philippines, Tristan d'Acunha to Bahia and Buenos Ayres, West Indies.						
Ananchytidæ ARE. GRAY.							
Palæobrissus A. AG.	West Indies.						
P. Hilgardi A. AG.	West Indies.						
Palæotropus LOV.	Tropical Atlantic, W. Indian.		..				H. [illegible] SH., La. H. [illegible] MARC., Tex.
P. Josephinæ LOV.	West Indies, Antilles.						
P. Thomsoni A. AG.	Atlantic Coast of U. S. (S. C.)						[illegible] nus D'ORB. Texas.
Homolampas A. AG.	Tropical Atlantic and Pacific. — Tertiary, Italy.						
H fragilis A. AG.	Florida, Brazil, Josephine Bk.						
Paleopneustes A. AG.	Tropical West Atlantic. — Eocene, Italy.	... ..		.		Archaeopneustes [illegible] bense COTT. A. Jimenoi COTT. Cuba.	
P. cristatus A. AG.	West Indies.					Macropneustes [illegible] Cuba.	Cardiaster cinctus D'ORB. N. J.
P hystrix A. AG.	West Indies.						

[illegible] West Indian Echini.	Principal Localities and Geological Range of Genus	Panamic Echini	Post-Pliocene	Pliocene	Miocene	Eocene.	Cretaceous.
Linopneustes A. Ag.	Tropical Atlantic and Pacific.						
L. longispinus A. Ag.	West Indies.					Eupatagus Clevei Cott. E. antillarum Cott. E. grandifloris Cott., St. Bart.	
Spatangina Gray.						Breynia cubensis Cott., Cuba.	
Spatangus Kl.	Atlantic, Indian, Pacific. Pliocene, Miocene, Eocene; Europe, Morea.						
S. purpureus Leske.	Norway, Mediterranean, Azores, Bermudas.						
Macropneustes Agass.	Miocene, Eocene Switzerland, France, Egypt, Italy, West Indies.						
M. spatangoides A. Ag.	West Indies.					M. cubensis Cott. Cuba.	
Echinocardium Gray.	Atlantic, Indian, Pacific. — Pliocene, Miocene, Eocene; N. Am., England, Italy, Switzerland, India.						
E. cordatum Gray.	Norway, Mediterranean, N. C. to Brazil.			Amphid. amplibotus M'Cr. S. C. A. virginianus Des., S. C., Va.			
E. flavescens A. Ag.	Norway, Cape Good Hope, S. C. and Florida.						
E. pennatifidum Norm.	Shetland Islands, Straits of Florida.				Amph. gothicus Rav., S. C.		
Brissina Gray.							
Hemiaster Des.	Southern Ocean, So. Pacific and Atlantic, Tropical Atlantic. Tertiary N. Am.; Cretaceous N. Am., Upper Chalk, India, Europe.					Prenaster Loveni Cott., St. Bart.	
H. expergitus Lov.	West Indies, East N. Atlantic.					Hemiaster Conradi Bouv., Ga.	H. stella Des. N. J., Ala.
H. zonatus A. Ag.	N. Brazil, Canary Islands.			H. cubensis D'Orb., Cuba.		H. antillensis Cott., Cuba.	H. Humphreysiana, M. & H. Texas.
H. Mentzi A. Ag.	West Indies.					H. Duvalqui Cott., Cuba.	

[illegible] West Indian Species	[illegible] Range of Genus.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Rhinobrissus A. Ag.	Tropical West Atlantic and Pa[illegible] — Tertiary (Miocene sp.) Australia.						
R. micrasteroides A. Ag.	West Indies.					Scutella antillarum Cott., St. Bart.	Hemiaster pseudaltus Des. Ala., Texas. H. [illegible] Des. Texas.
Brissopsis Agass.	Atlantic, Indian, Pacific. — Tertiary, Europe, India, N. A., West Indies.	Leiocidaris antillarum Lyc.					
B. lyrifera Agass.	Norway, Mediterranean, Greenland, Cape of Good Hope, West Indies.				B. Jimenoi Cott. Cuba. B. [illegible] Cott., Anguilla		
Aerope Wyv. Thom.							
A. rostata Wyv. Thom.	Arafura Sea, Bay of Biscay, Davis Straits, N. E. coast of U. S. off Martha's Vineyard, U. S. Fish Com.						
Aceste Wyv. Thom.							
A. bellidifera Wyv. Thom.	Sandwich Islands to Low Archipelago, Buenos Ayres to Tristan d'Acunha, Canary Islands.						
Agassizia Val.	[illegible] Atlantic, Antarctic and Pacific. — Miocene, Eocene; Egypt, N. Am., West Indies.						
A. excentrica A. Ag.	West Indies.	Agassizia scobina cubita Val.		A. [illegible] McCr. A. [illegible] McCr., S. C.	A. porifera McCr., S. C.	A. Clevei Cott. St. Bart., Anguilla	
Brissus Kl.	Tropical Atlantic, Indo-Pacific. — Eocene, Miocene, Lower; N. Am., West Indies, Pyrenees, Malta, Europe, Java.						
B. Damesi A. Ag.	N. Brazil, Azores.						
B. unicolor Kl.	West Indies, Cape Verde Islands, [illegible]	Brissus obesus Verr.		B. [illegible] Ag. Gosse Isl. B. [illegible] McCr., S. C.	B. [illegible] McCr., S. C. B. exiguus Cott. Anguilla		
Metalia Gray	[illegible] Atlantic, Indo-Pacific. — Tertiary, West Indies, N. Am., Malta, Italy.						

(Caribbean) West Indian Echini.	Principal Localities and Geological Range of Genus.	Panamic Echini.	Post Pliocene.	Pliocene.	Miocene.	Eocene.	Cretaceous.
M. pectoralis A. Ag.	West Indies, Brazil.	M. maculosa A. Ag.		Plagion. Holmesii Mc Cr. Plagion. Ravenelianus Mc Cr. S. C.		Plag. Loveni Cott., St. Bart.	
Meoma Gray.	Tropical Atlantic and Pacific. — American Tertiary, Australia, West Indies, Cuba.						
M. ventricosa Lütk.	West Indies.	M. grandis Gray			Peripneustes Clevei Cott. Anguilla.	Peripn. antillarum Cott. St. Bart.	
Schizaster Agass.	Atlantic, Indian, Pacific. — Miocene, Eocene; Europe, India, Java, Australia, N. Am., West Indies.						
S. fragilis Agass.	Norway, Maine, East Coast of U. S. (Middle States), West Indies, Cape of Good Hope.					Sch. subcylindriens Cott. St. Bart.	
S. orbignyanus A. Ag.	West Indies, off Martha's Vineyard, U. S. Fish Com.*				Sch. Clevei Cott. Sch. Loveni Cott., Anguilla.		Spat. ungulata Mort., N.J.
Periaster D'Orb.	West Indies, Arafura Sea. — Eocene, Europe, Egypt, Java, India, West Indies; Chalk, Egypt, France, N. Am.				Sch. Scillæ Agass. Sch. Parkinsoni Ag., Anguilla.		
P. limicola A. Ag.	Arafura Sea, West Indies.					P. elongatus Cott., St. Bart.	P. texanus Des. Texas.
Moira A. Ag.	Tropical Atlantic and Pacific. — American Tertiary, West Indies.						
M. atropos A. Ag.	N. C. to West Indies.	Moira clotho A. Ag.	Sch. atropos Auct., S. C. M. lachesis Gir. S. C.				

* The Echini collected by the U. S. Fish Com. Steamer "Albatross" have lately been placed in my hands for examination by the kindness of Professors Baird and Verrill. I was unable to examine this small but interesting collection in time to incorporate the results in this Report. — A. Ag.

PLATE I.

Dorocidaris Blakei A. Ag.

Fig. 1. Seen from above. Natural size.
Fig. 2. Seen in profile. Natural size.

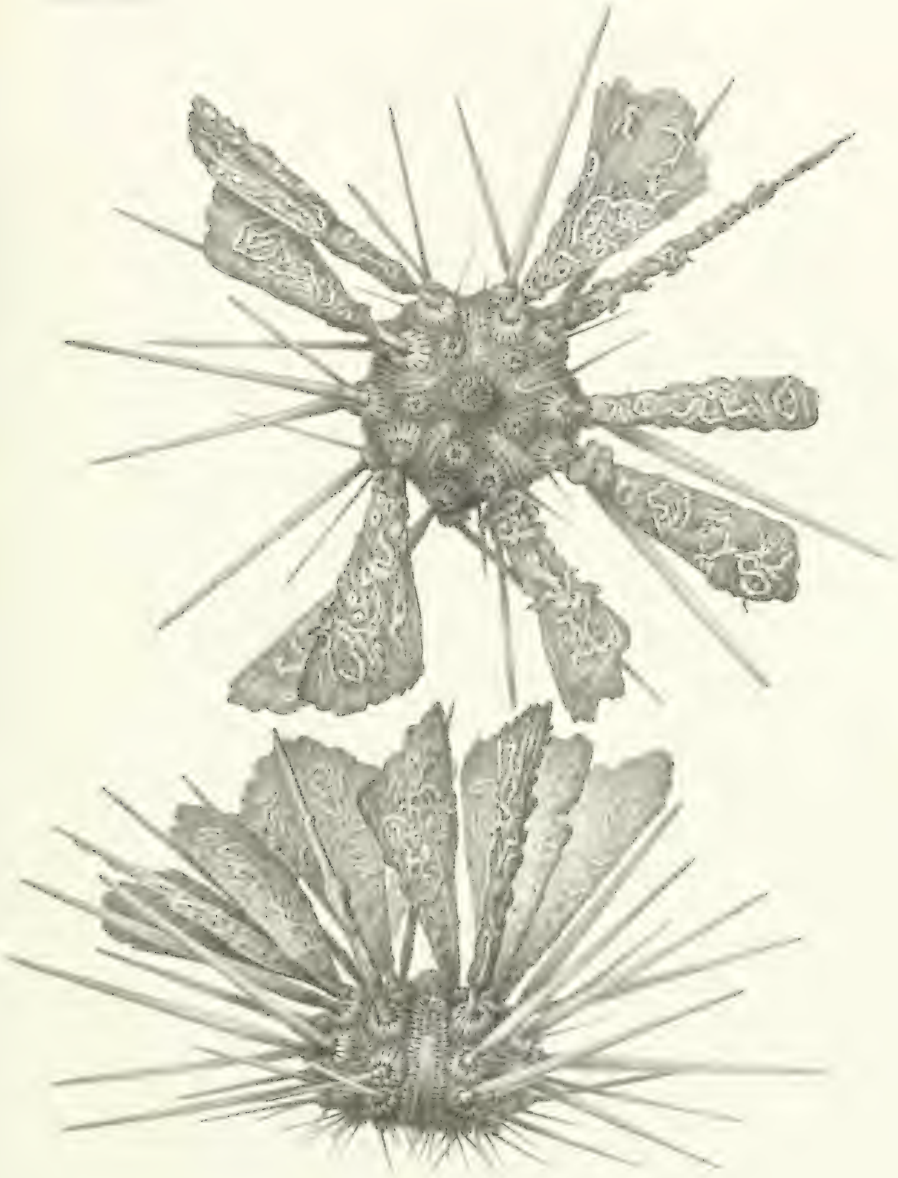

PLATE II.

1–15. **Dorocidaris Blakei** A. Ag.

Fig. 1. Portion of test seen in profile, facing the median interambulacral line, from a specimen 37 mm. in diameter.

Fig. 2. Abactinal system of same.

Fig. 3, 4. Primary elongate radioles, similar to those of *D. papillata*.

Fig. 5. Primary radiole, somewhat flattened at extremity.

Fig. 6, 7. Primary radioles somewhat flattened and slightly fan-shaped at extremity.

Fig. 8–10. Primary radioles still more fan-shaped than those of the preceding figures.

Fig. 11–13. Small interambulacral radioles of the actinal side near actinostome.

Fig. 14, 15. Larger and stouter radioles of the actinal side near the ambitus.

16–27. **Dorocidaris Bartletti** A. Ag.

Fig. 16. Portion of test seen in profile, showing the ambulacral area and a few primary plates of the interambulacral area, adjoining the apical system, from a specimen 50 mm. in diameter.

Fig. 17. Abactinal system of same.

Fig. 18–27. Different primary radioles taken from a single specimen, showing the more or less serrated structure between the two extremes of Fig. 23 and 27.

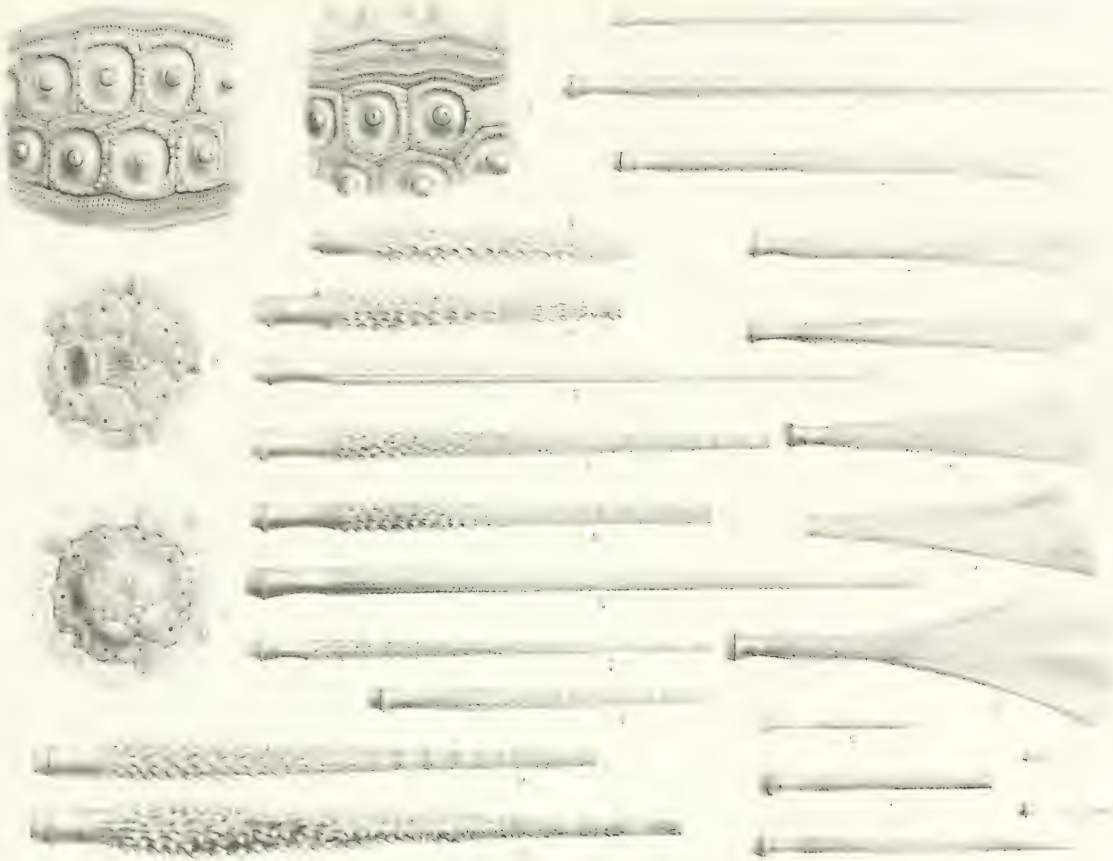

PLATE III.

Porocidaris Sharreri A. Ag.

Seen in profile. Natural size.

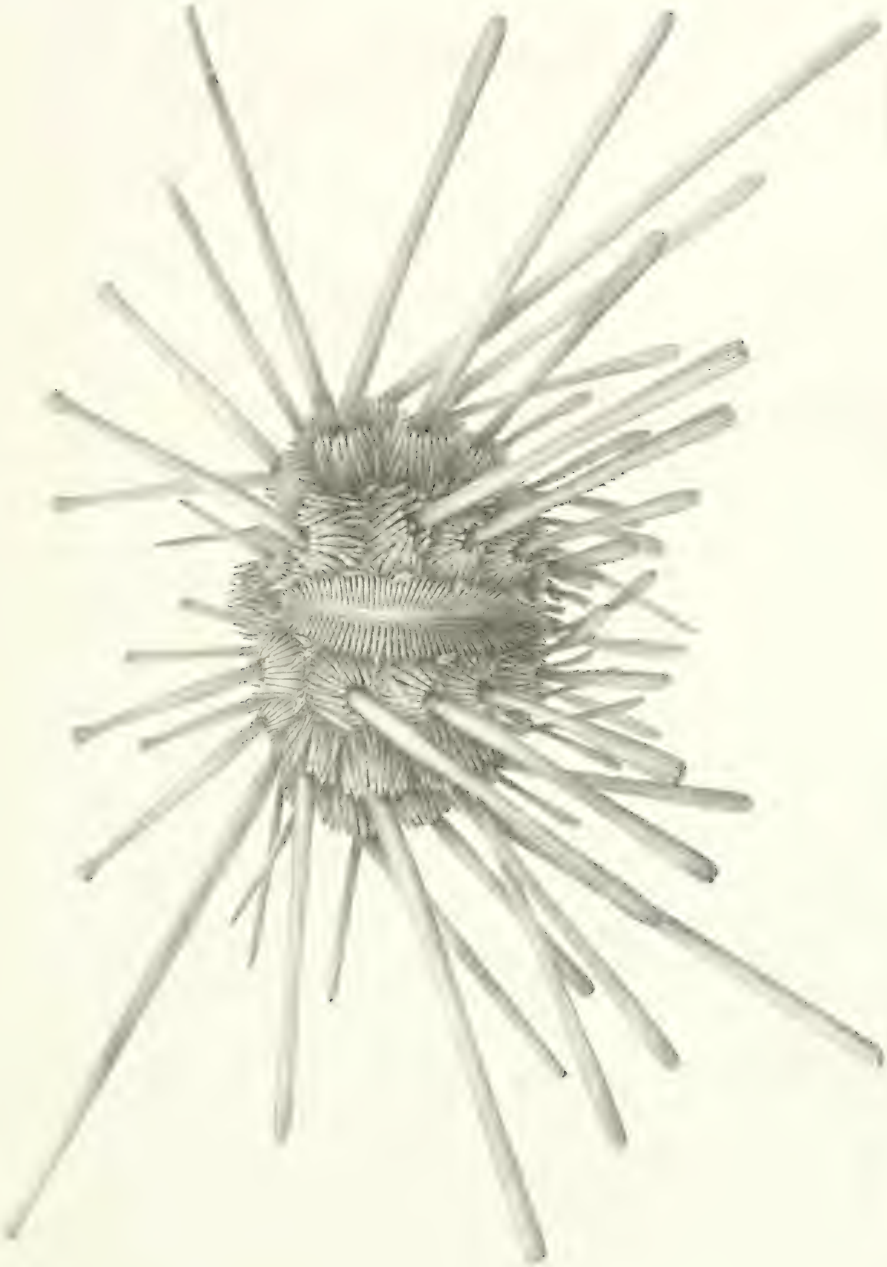

PLATE IV.

1–2. **Porocidaris Sharreri** A. Ag.

Fig. 1. Portion of test of specimen measuring nearly three inches in diameter. Seen in profile.
Fig. 2. Abactinal system of same, both figures somewhat enlarged.

3–23. **Salenia Pattersoni** A. Ag.

Fig. 3. Abactinal system of specimen 18 mm. in diameter.
Fig. 4. Actinal system of same.
Fig. 5. Portion of test of same, seen in profile, showing primary coronal plates above ambitus, facing the median interambulacral line.
Fig. 6. Portion of test of same above the ambitus, seen in profile facing the median ambulacral line.
Fig. 7. Portion of ambulacral area of same, showing the Hemicidaris-like arrangement of the tubercles at the base of the ambulacral area near the actinostome.
Fig. 8 Primary spine of same. Natural size.
Fig. 9–11. Ambulacral papillæ of same, magnified.
Fig. 12–14. Porocidaris-like interambulacral spines, near actinostome, magnified.
Fig. 15. Test of specimen 12 mm. in diameter, seen from the abactinal side.
Fig. 16. Portion of test of same, below and at ambitus, seen in profile, facing the median ambulacral line and showing the Hemicidaris-like ambulacral tubercles.
Fig. 17. Actinal system of same.
Fig. 18. Abactinal system of specimen 10 mm. in diameter.
Fig. 19. Actinal system of same.
Fig. 20. Portion of test of same, above ambitus, seen in profile, facing the median interambulacral line.
Fig. 21. Portion of test of same, below and at ambitus, seen facing the median ambulacral line, to show the Hemicidaris-like arrangement of the ambulacral tubercles.
Fig. 22. Young Salenia 6.5 mm. in diameter, seen from the actinal side.
Fig. 23. Abactinal system of same.

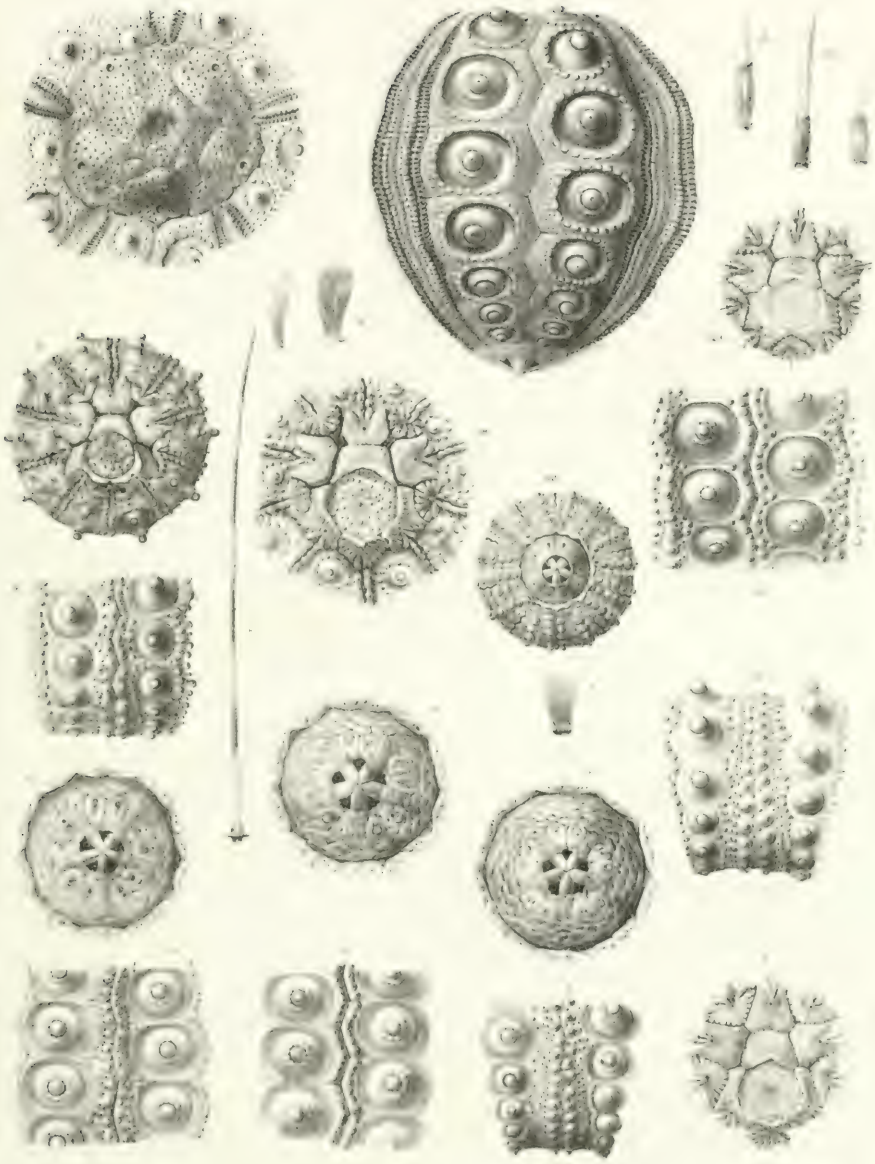

PLATE V.

Salenia Pattersoni A. Ag.

Fig. 1. Seen from above. Natural size.
Fig. 2. Seen in profile. Natural size.
Fig. 3. Seen from the actinal side. Natural size.

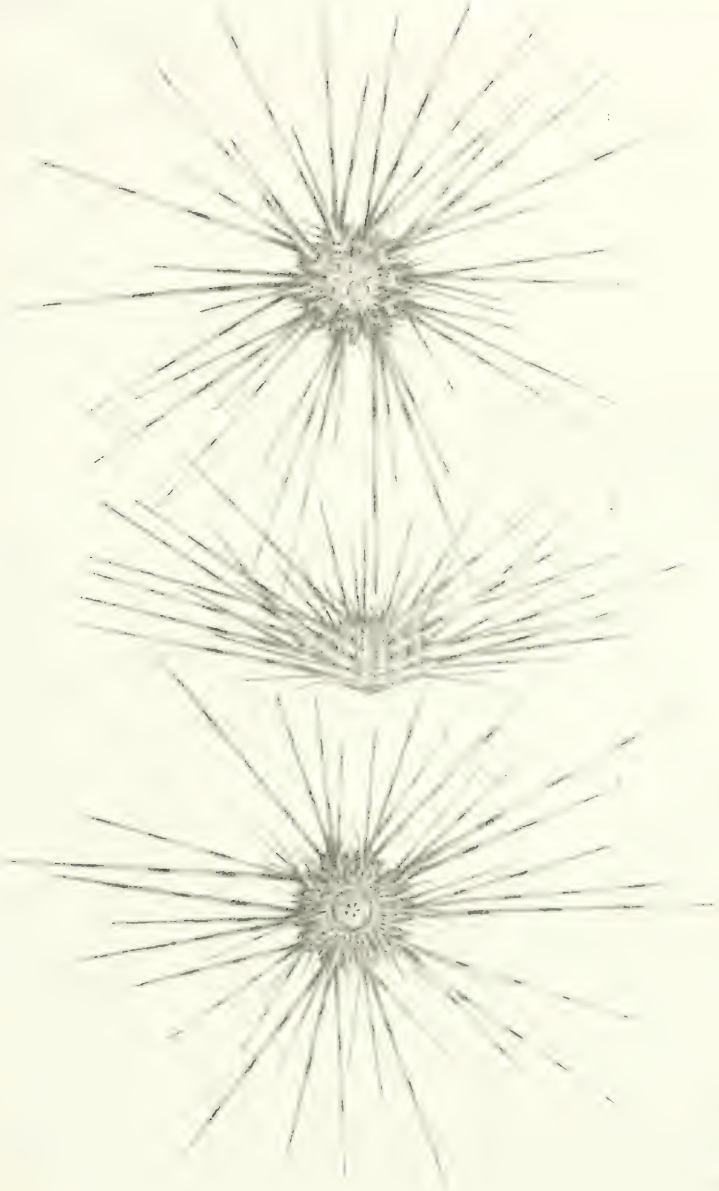

PLATE VI.

1–17. **Salenia varispina** A. Ag.

Fig. 1. Young Salenia measuring 1.5 mm. (diameter of test), showing the fimbriated primary spines, and the plates of the anal system.

Fig. 2. Young Salenia 3 mm. in diameter, seen from the actinal side.

Fig. 3. The same as Fig. 2, seen from the abactinal side.

Fig. 4. Inner view of the abactinal system of a Salenia 8 mm. in diameter.

Fig. 5. Part of actinal system, showing the imbricated plates in a young Salenia 7 mm. in diameter.

Fig. 6. Part of the abactinal system of a young Salenia 2 mm. in diameter, showing the indistinct lozenge-shaped arrangement of the primary striation of the test.

Fig. 7. Actinal termination of one of the ambulacral areas, showing the position of the sphæridia and of one of the pairs of buccal tentacles of a Salenia 8 mm. in diameter.

Fig. 7′. Interambulacral actinal area, showing also single sphæridia near the actinal extremity in each of the ambulacral areas.

Fig. 8. Magnified view of one of the pyriform sphæridia.

Fig. 9–11. Magnified views of interambulacral papillæ.

Fig. 12. Sessile papillæ of the anal system.

Fig. 13. Tube projecting beyond the genital opening.

Fig. 14. Young forked primary spines of Fig. 1.

Fig. 15. Stout-headed, short-stemmed trifid pedicellaria of the actinal surface.

Fig. 16. One of the gills of a Salenia 8 mm. in diameter.

Fig. 17. Sessile papillæ of one of the genital plates of the abactinal system, covered with large pigment spots, and still showing the primary striation.

18–23. **Salenia Pattersoni** A. Ag.

Fig. 18. Actinal part of ambulacral area of Salenia 14 mm. in diameter, showing the gills, the imbricating plates, and one of the pairs of the buccal tentacles of the actinostome.

Fig. 19. Interambulacral part of actinostome of another Salenia 14 mm. in diameter, showing the imbricating plates of the actinostome and a pair of the large buccal tentacles, with comparatively slender long-stemmed pedicellariæ.

Fig. 20. Part of actinostome of another Salenia of nearly the same size: the granulation of the actinal plates is coarser.

Fig. 21. The left posterior genital plate, showing the coarse granulation characteristic of the abactinal system of this species, with minute globular sphæridia in the notches of the plates, these globular sphæridia are similar to the pair of small, short-stemmed sphæridia found at the base of the ambulacral tentacles near the actinostome.

Fig. 22. Part of coronal plates of test of Salenia 14 mm. in diameter.

Fig. 23. Granulation of anal plate.

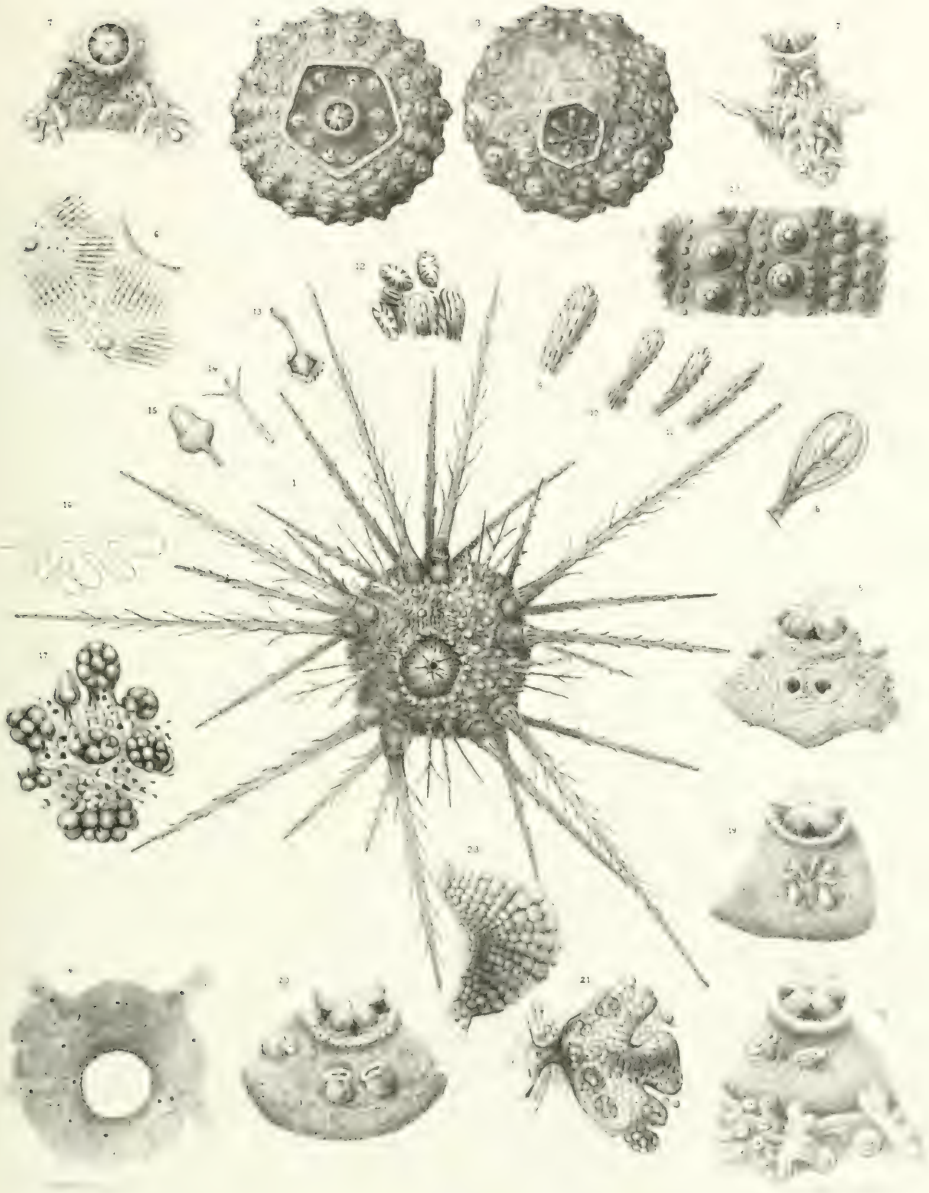

PLATE VII.

Cœlopleurus floridanus A. Ag.

Fig. 1. Seen from above. Natural size.

Fig. 2. Same, seen from the actinal side, to show the bat-shaped spines of the actinal region.

Fig. 3. A smaller specimen, seen from above. Natural size.

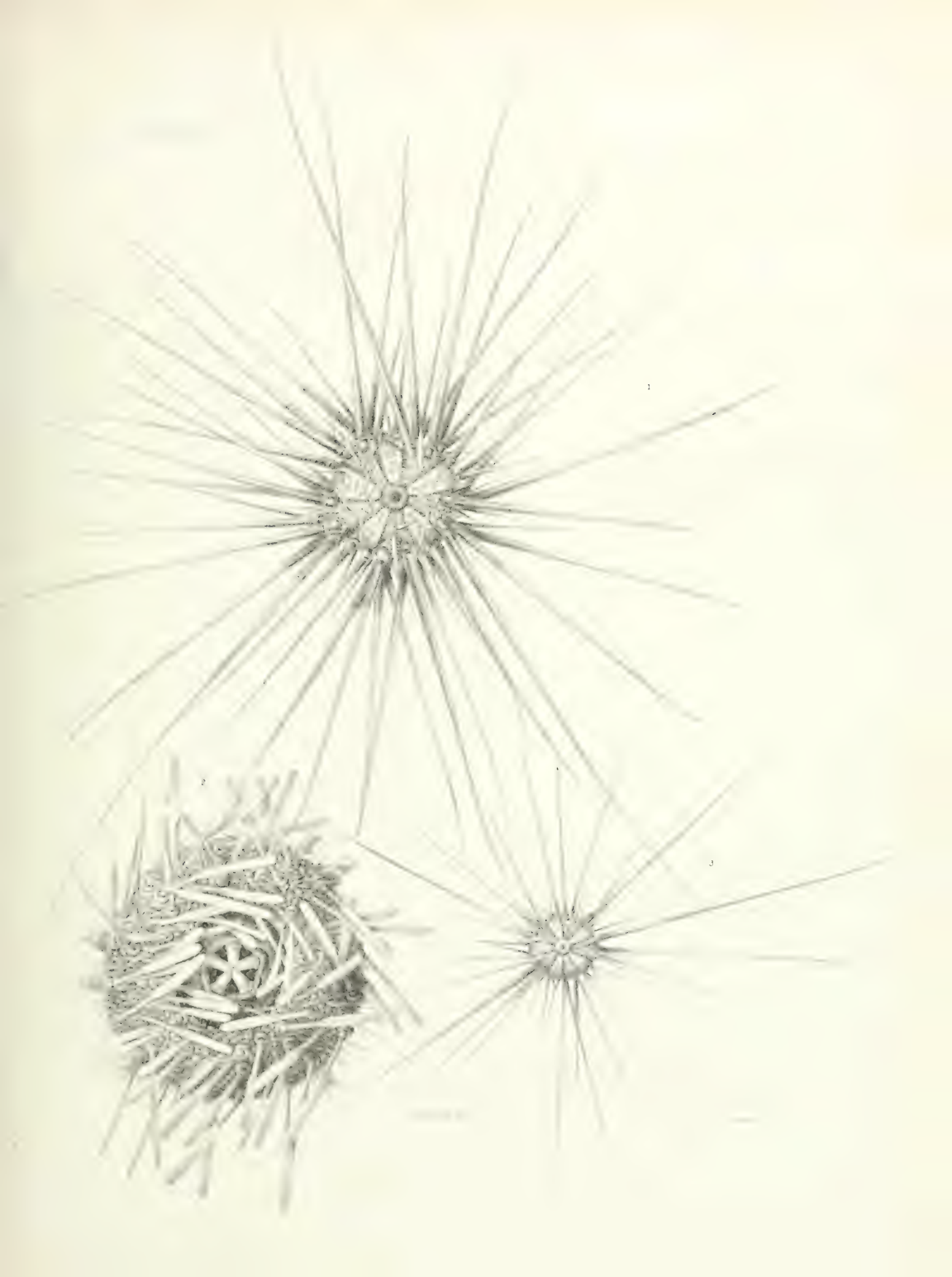

PLATE VIII.

Cœlopleurus floridanus A. Ag.

Fig. 1. Test of specimen measuring 28 mm., seen from the abactinal pole.
Fig. 2. Portion of test of the actinal surface of same, somewhat more magnified.
Fig. 3. Portion of test of same, seen in profile, facing the median ambulacral line.
Fig. 4. Portion of test of same, seen in profile, facing the median interambulacral line.
Fig. 5. Portion of test, still more enlarged, to show the pits at the base of the median ambulacral line.
Fig. 6. Abactinal system of same specimen.
Fig. 7. Specimen 11 mm. in diameter, seen from the abactinal pole.
Fig. 8. Apical system of same.
Fig. 9. Portion of test of same, seen in profile, facing the median ambulacral line.
Fig. 10. Portion of test of same, seen in profile, facing the median interambulacral line.
Fig. 11. Specimen 9 mm. in diameter, seen from the abactinal pole.
Fig. 12. Apical system of same.
Fig. 13. Portion of test of same, seen in profile, facing the median ambulacral line.
Fig. 14. Portion of test of same, seen in profile, facing the median interambulacral line.
Fig. 15. Small specimen 6 mm. in diameter, seen from the abactinal pole.
Fig. 16. Portion of test of same, seen in profile, facing the median interambulacral line.
Fig. 17. Portion of test of same, seen in profile, facing the median ambulacral line.
Fig. 18. Apical system of same.

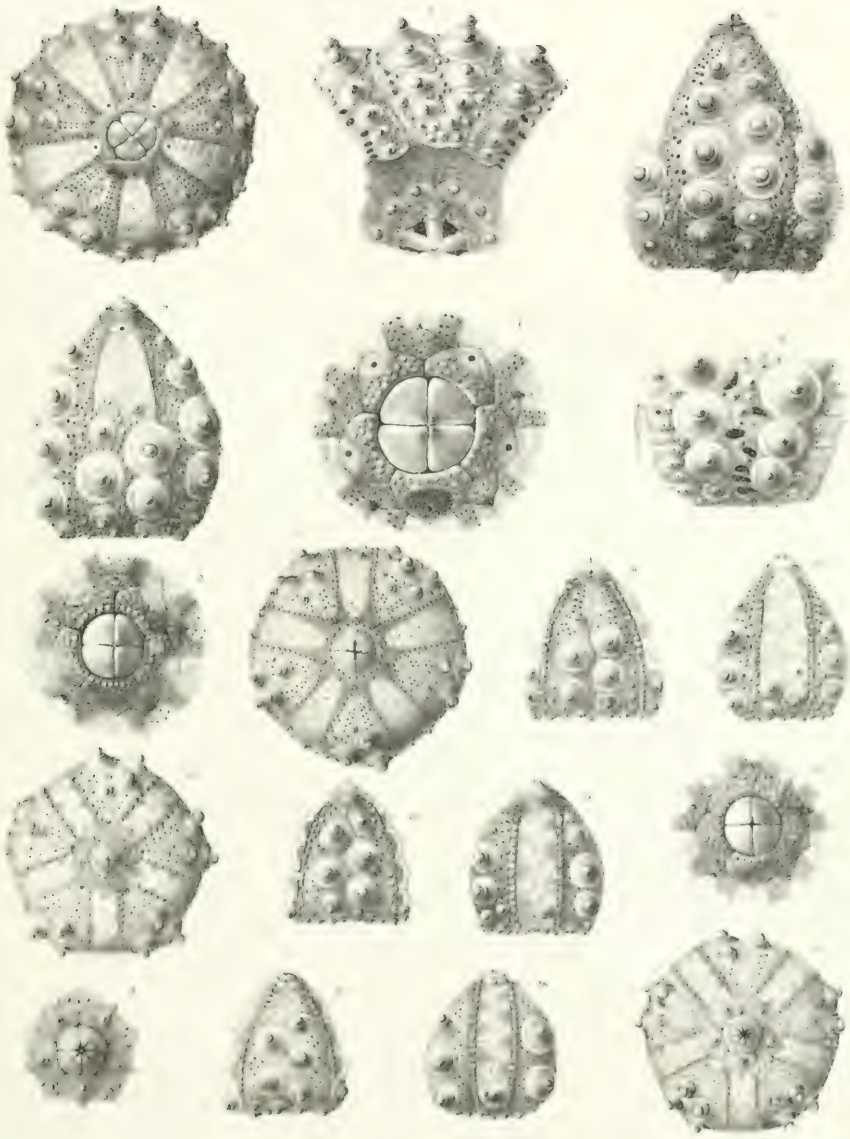

PLATE IX.

Aspidodiadema antillarum A. Ag.

Fig. 1. Specimen with spines, test 11 mm. in diameter, seen in profile.

Fig. 2. Same with the spines cut off, seen facing an ambulacral area, showing the sheathed pedicellariæ.

Fig. 3. Portion of test of a specimen 11 mm. in diameter, seen from the actinal side; denuded.

Fig. 4. Portion of test of same as Fig. 3, seen from the abactinal pole; denuded.

Fig. 5. Actinostome, with termination of the adjoining ambulacral areas, showing the suckers, the gills, and the large buccal tentacles of Fig. 2.

Fig. 6. Portion of denuded test of specimen 11 mm. in diameter, seen facing one of the ambulacral areas.

Fig. 7. The same as Fig. 6, seen facing one of the interambulacral areas.

Fig. 8. Denuded test of specimen 9 mm. in diameter, seen from the actinal side.

Fig. 9. Genital ring of same, somewhat more magnified.

Fig. 10. One of the sheathed ambulacral pedicellariæ, greatly magnified.

Fig. 11. Long-stemmed, long-headed trifid flexible pedicellaria, placed above ambitus.

Fig. 12. Magnified view of a piece of the basal part of a primary radiole.

Fig. 13. Large hyaline, globular, short-stemmed ambulacral sphæridia, found near the abactinal system; magnified.

Fig. 14. Smaller, long-stemmed actinal ambulacral sphæridia; magnified.

Fig. 15. Young sheathed pedicellaria.

Fig. 16. Small, short-headed, short-stemmed trifid ambulacral pedicellaria.

Fig. 17. Actinostome of young Aspidodiadema measuring 5 mm. in diameter.

Fig. 18. Genital ring and anal system of same specimen: neither the ocular nor the genital pores are as yet formed in this specimen.

Fig. 19. Young Aspidodiadema 6 mm. in diameter, seen from the actinal side: the primary spines are cut off.

Fig. 20. The same as Fig. 19, seen from the abactinal pole, showing the anal proboscis.

Fig. 21. Genital ring of small Aspidodiadema 3.5 mm. in diameter: the genital pores are already formed.

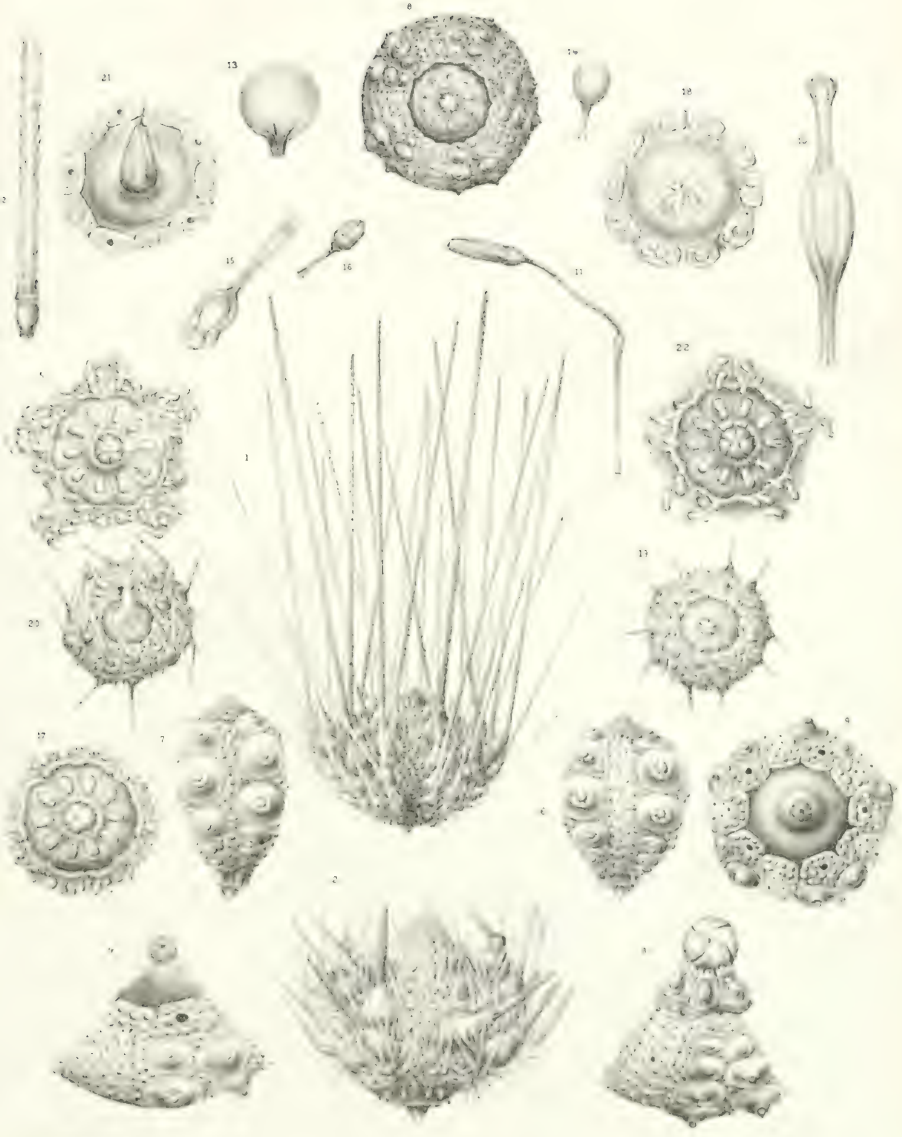

PLATE IX[a].

Aspidodiadema Jacobyi A. Ag.

Fig. 1. Specimen covered with spines seen from the abactinal pole, natural size.
Fig. 2. Denuded specimen, 23 mm. in diameter, seen from the abactinal side.
Fig. 3. The same as Fig. 2, seen from the actinal side.
Fig. 4. Abactinal system of same, somewhat more magnified.
Fig. 5. Actinal system of same.
Fig. 6. Magnified portion of test of same, seen facing one of the interambulacral areas.
Fig. 7. Same as Fig. 6, seen facing one of the ambulacral areas.
Fig. 8. Portion of test, seen facing one of the ambulacral areas, showing the suckers and the sheathed pedicellariæ.
Fig. 9. One of the sheathed pedicellariæ, greatly magnified.
Fig. 9'. The same, seen in profile.
Fig. 10. Aspidodiadema denuded, seen in profile, 12 mm. in diameter.
Fig. 11. The same as Fig. 10, seen from the abactinal pole.
Fig. 12. The same as Fig. 10, seen from the actinal side.
Fig. 13. Genital ring of same, somewhat more magnified.
Fig. 14. Actinostome of same.
Fig. 15. Portion of test of same, seen in profile, somewhat more magnified than in Fig. 10, seen facing one of the ambulacral areas.
Fig. 16. The same as Fig. 15, seen facing one of the interambulacral areas.
Fig. 17. Young specimen 6 mm. in diameter, seen from the abactinal side.
Fig. 18. The same as Fig. 17, seen in profile.
Fig. 19. The same, seen from the actinal side.
Fig. 20. Genital ring of a young specimen 3 mm. in diameter, before the formation of the genital or ocular pores, showing the anal proboscis.

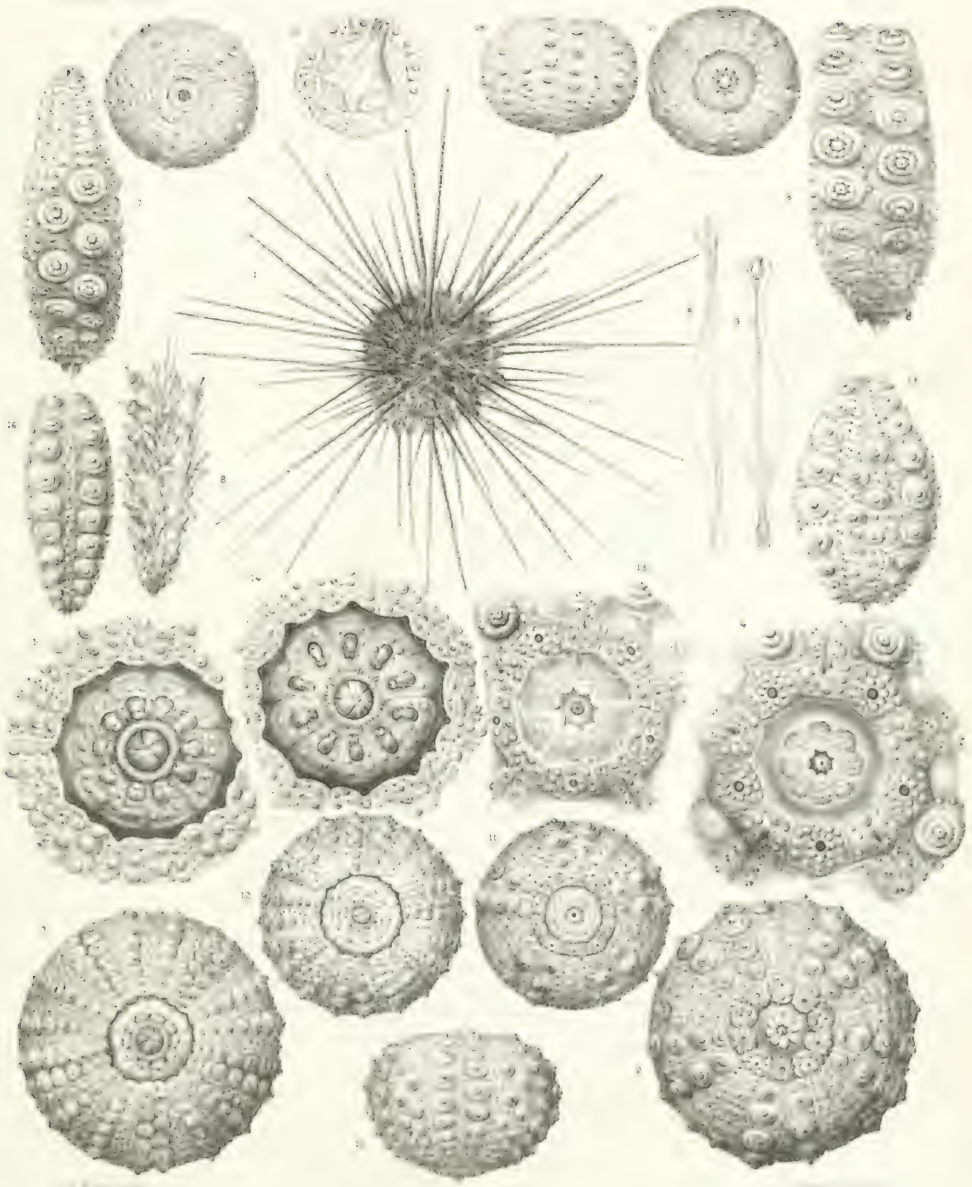

PLATE X.

Phormosoma uranus Wyv. Thoms.

Seen from the abactinal pole, fully expanded, natural size.

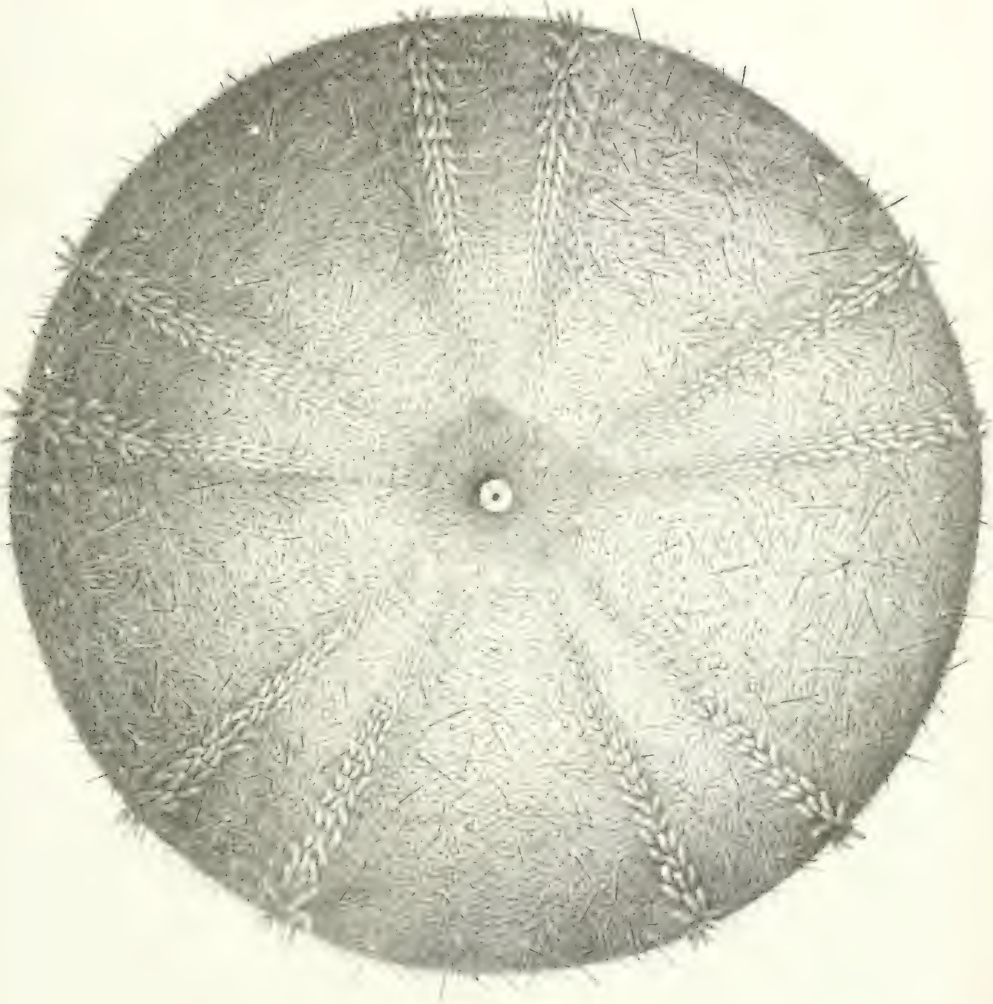

PLATE XI.

Phormosoma uranus Wyv. Thoms.

Fig. 1. Seen in profile, fully expanded, as it comes up in the trawl.
Fig. 2. Denuded abactinal system of specimen about 170 mm. in diameter.
Fig. 3. Actinal system of same.
Fig. 4. Portion of test of actinal surface denuded, close to the ambitus.
Fig. 5. Portion of test of median abactinal surface.

Figs. 2 and 3 are enlarged twice, all other figures natural size.

PLATE XII.

Phormosoma placenta Wyv. Thoms.

Fig. 1. Seen in profile, natural size.
Fig. 2. Same seen from the abactinal side.
Fig. 3. Same seen from the actinal side.
Fig. 4. Portion of actinal system denuded, magnified.
Fig. 5. Coronal plates of the abactinal side, near the ambitus, magnified.
Fig. 6. Edge of test, showing the ambital fasciole from the abactinal side, magnified.
Fig. 7. Portion of test, facing the ambital fasciole, magnified.
Fig. 8. One of the club-shaped spines of the actinal surface, magnified.
Fig. 9. Denuded abactinal system, somewhat magnified.

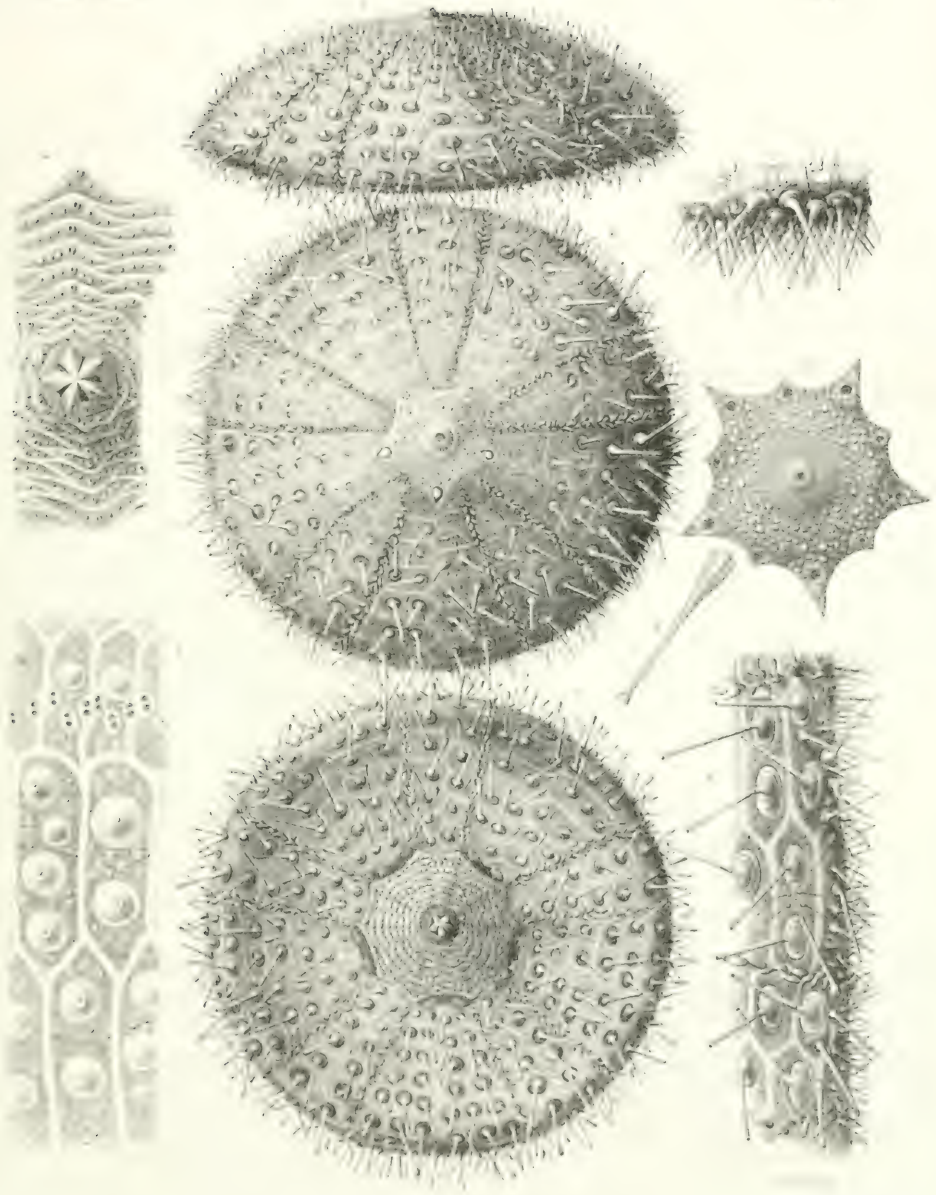

PLATE XIII.

Asthenosoma hystrix Wyv. Thoms.

Seen from the abactinal pole, fully expanded, natural size.

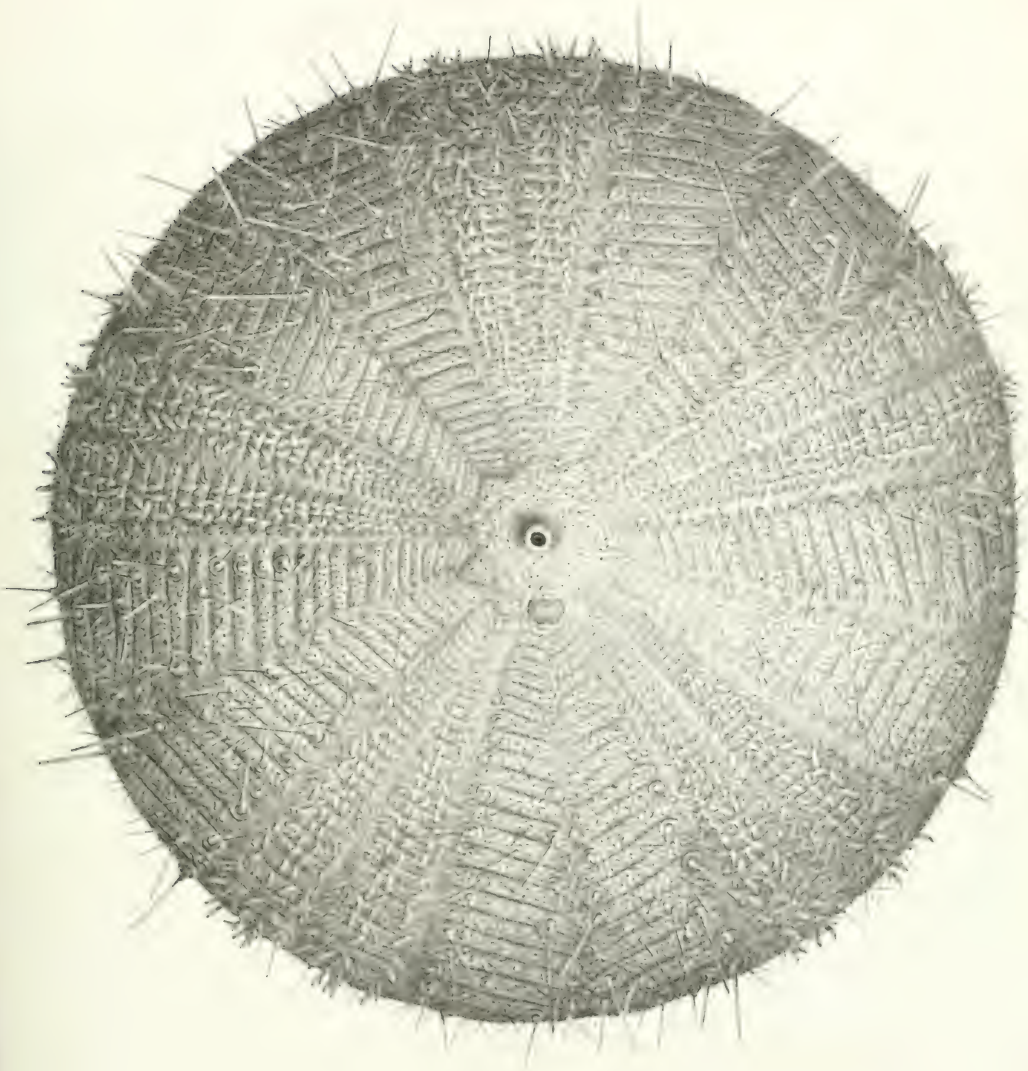

PLATE XIV.

Asthenosoma hystrix Wyv. Thoms.

Fig. 1. Seen in profile, fully expanded as it comes up in the trawl.

Fig. 2. Abactinal system of specimen about 160 mm. in diameter, denuded.

Fig. 3. Actinal system of same, denuded, showing the arrangement of the actinal plates and the position of the small digitate gills.

Fig. 4. Portion of test of same, denuded, on the median actinal side.

Fig. 5. Portion of test of same, denuded, on the median abactinal side.

Figs. 2, 3, $(\frac{2}{1})$; all others, natural size.

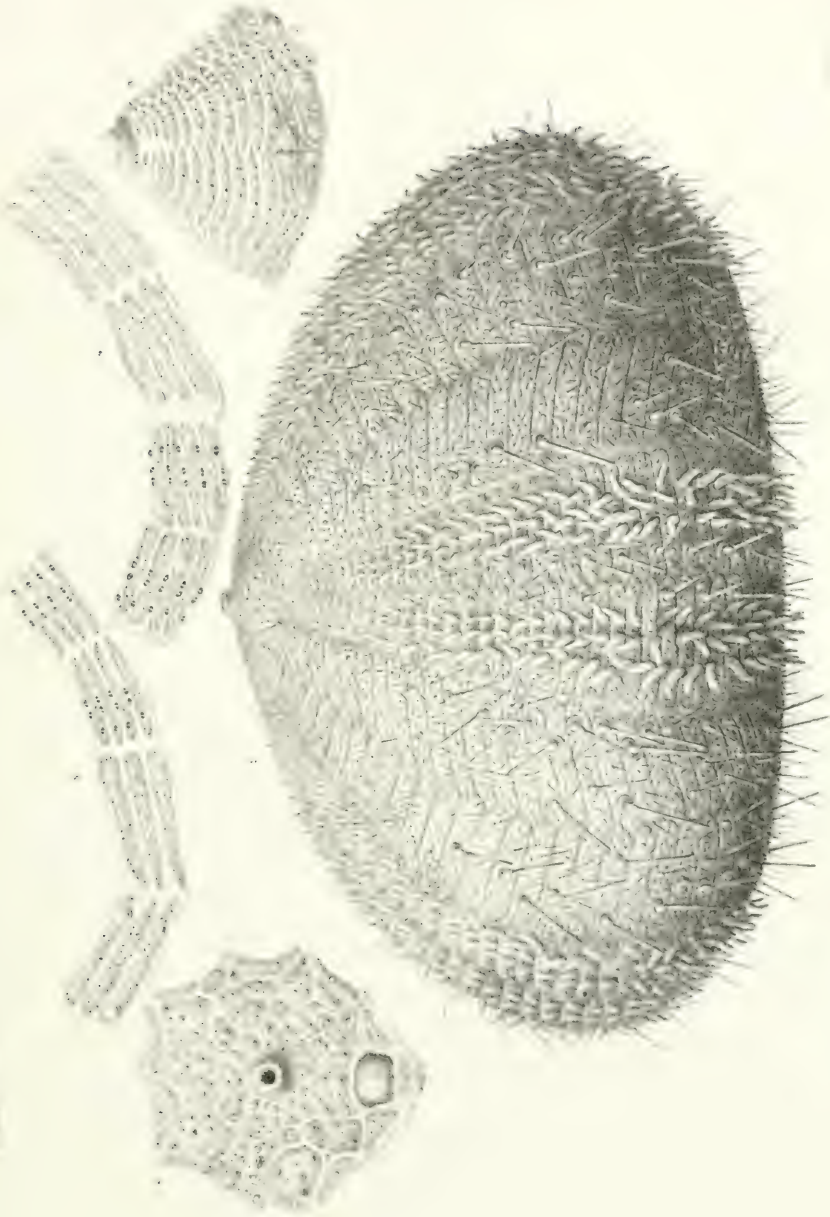

PLATE XV.

1, 2. **Astropyga sp.**

Fig. 1. Abactinal system of young Astropyga 13 mm. in diameter.

Fig. 2. Actinostome of same.

3–19. **Phormosoma placenta** Wyv. Thoms.

Fig. 3. Young Phormosoma 8 mm. in diameter, showing the abactinal system, and a part of the test.

Fig. 4. Somewhat younger specimen 8 mm. in diameter, seen from the actinal side, showing the sphæridia, suckers, and pedicellariæ of that side of the test.

Fig. 5. Somewhat older Phormosoma 17 mm. in diameter, seen from the abactinal side of the test.

Fig. 6. The same, seen from the actinal side.

Fig. 7. Older specimen 20 mm. in diameter, seen from the actinal side.

Fig. 8. The same, seen from the abactinal side.

Fig. 9. Older specimen 28 mm. in diameter, seen from the abactinal side.

Fig. 10. The same, seen from the actinal side.

Fig. 11. Phormosoma 41 mm. in diameter, seen from the abactinal side.

Fig. 12. The same, seen from the actinal side.

Fig. 13. Portion of anal system of young Phormosoma, 22 mm. in diameter, showing the mode of deposition of the limestone meshes forming the anal plates.

Figs. 14–19 show the gradual passage of mere accumulations of limestone cells, as in Fig. 14, which indicate the first position of the future tubercles, to Figs. 16, 15, 17, 18, and 19, in which the scrobicular ring, the mammary boss, and the perforation of the future tubercles are little by little indicated.

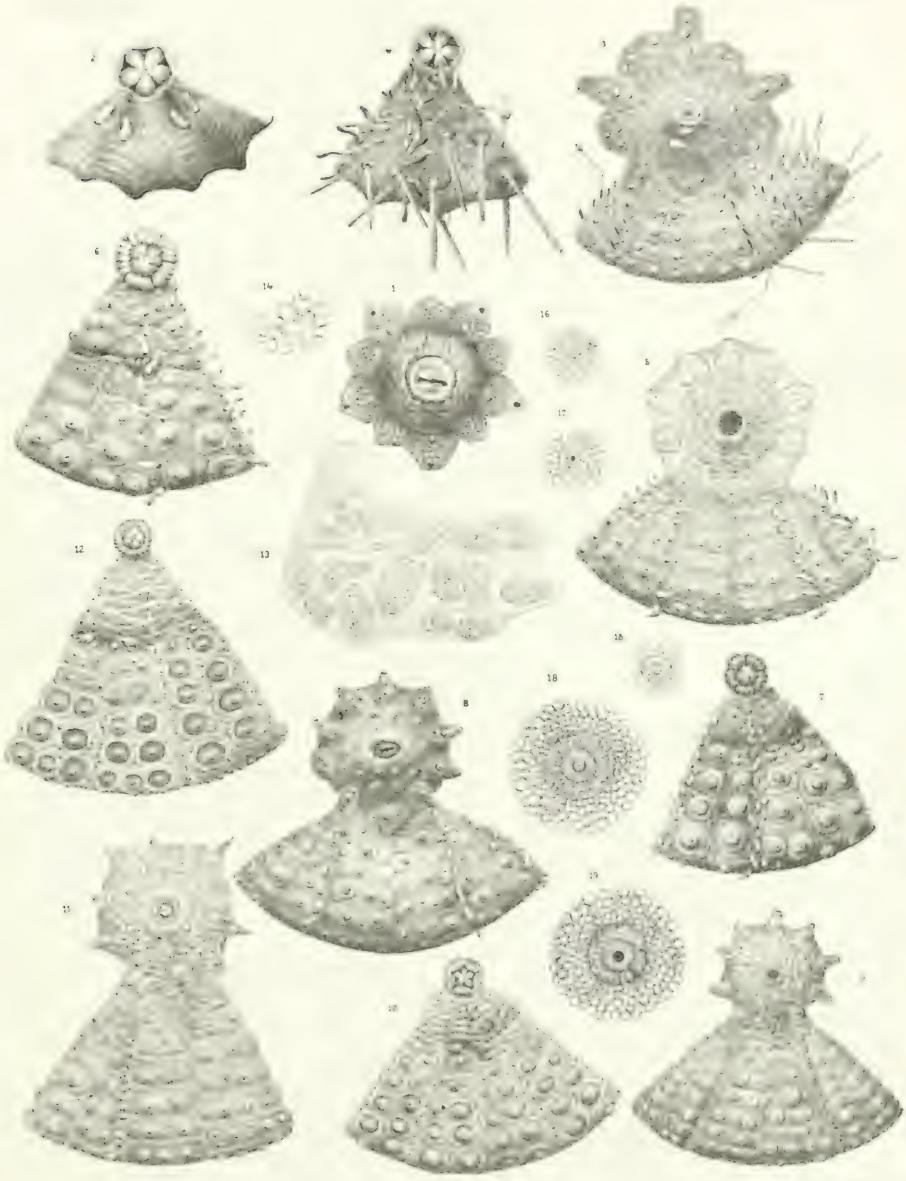

PLATE XV[a].

Clypeaster subdepressus AGASS.

Fig. 1. Seen from above, natural size ; half the test denuded.
Fig. 2. The same, seen from the actinal side.
Fig. 3. Part of one of the median ambulacral zones of the actinal side, somewhat magnified.
Fig. 4. Part of one of the median interambulacral zones of the abactinal side, magnified.

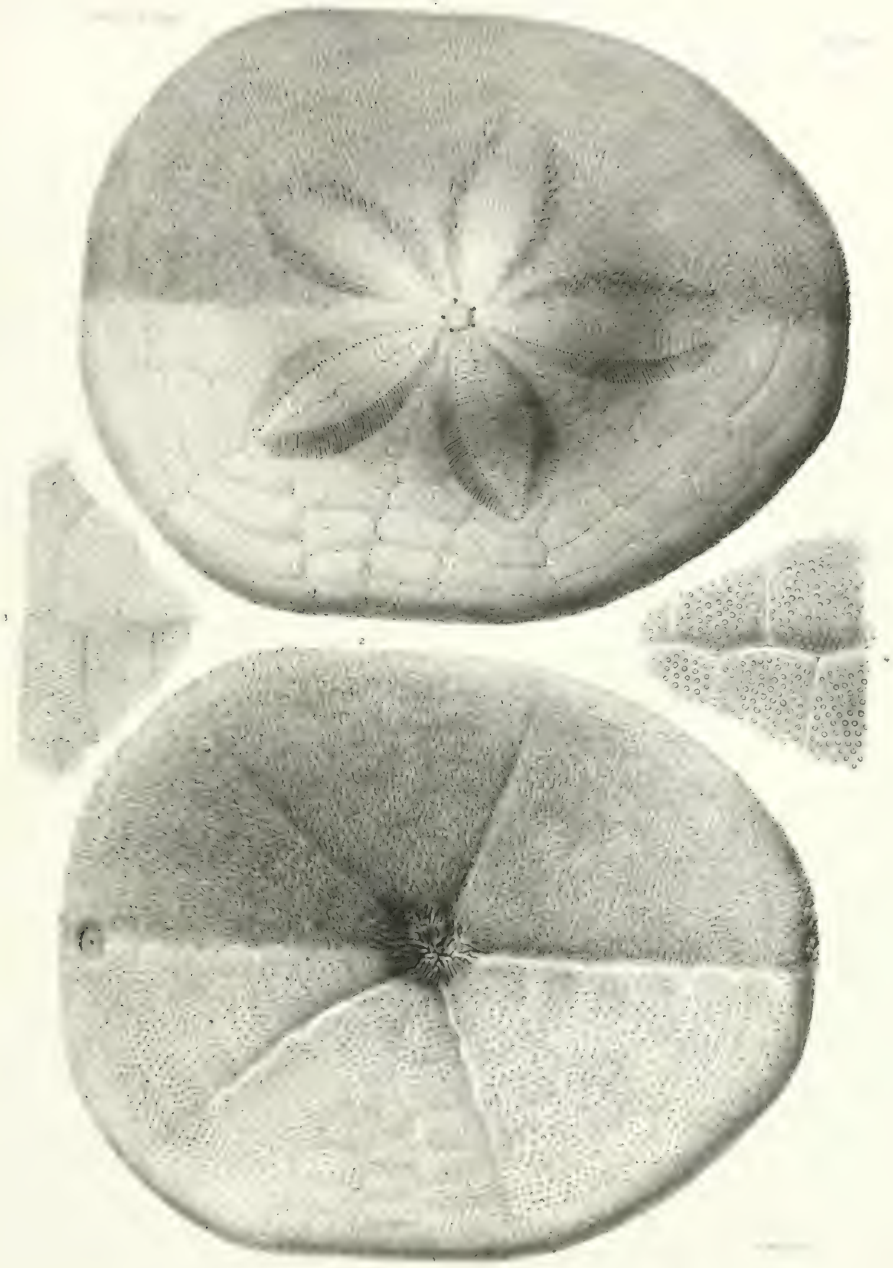

PLATE XV.

1, 2. **Clypeaster Ravenellii** A. Ag.

Fig. 1. Seen from the actinal side, natural size, one half of the test denuded.
Fig. 2. Part of one of the median ambulacral zones of the actinal side, magnified.

3, 4. **Clypeaster latissimus** A. Ag.

Fig. 3. Seen from the actinal side, natural size.
Fig. 4. Part of one of the ambulacral zones of the actinal side, magnified.

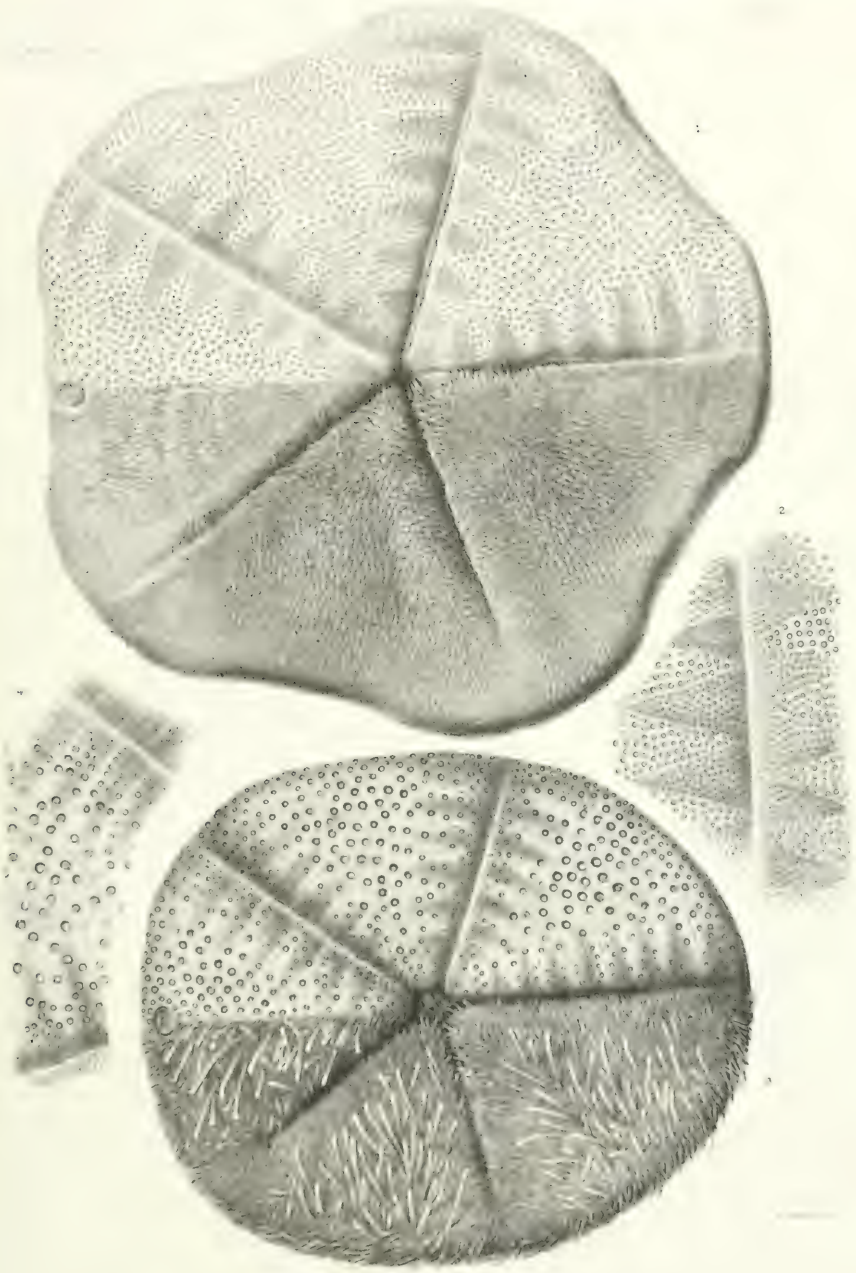

PLATE XVI.

Echinolampas depressa GRAY.

FIG. 1. Seen from above, denuded, natural size.
FIG. 2. The same, seen from the actinal side.
FIG. 3. The same, seen in profile.
FIG. 4. Actinostome, enlarged.
FIG. 5. Abactinal system, enlarged.
FIG. 6. Right anterior ambulacrum, enlarged.
FIG. 7. Interambulacral plates from the actinal side of the test.
FIG. 8. Left interambulacral plates from the area above the ambitus.
FIG. 9. Anal system.

PLATE XVII.

Conolampas Sigsbei A. Ag.

Fig. 1. Seen from the actinal side, denuded, natural size.
Fig. 2. The same, seen from the interior of the test, natural size.
Fig. 3. Abactinal system.
Fig. 4. Actinal system, seen from the interior of the test.
Fig. 5. The same as Fig. 4, seen from the actinal side.
Fig. 6. Anal system.
Fig. 6a. Interior view of the same.
Fig. 7. Portion of the right anterior ambulacrum.
Fig. 8. A piece of the same seen from the interior of the test.
Fig. 9. Plates of the lateral posterior interambulacral region of the median region of the test.
Fig. 10. Plate of the lateral posterior interambulacral region of actinal side adjoining the ambitus.

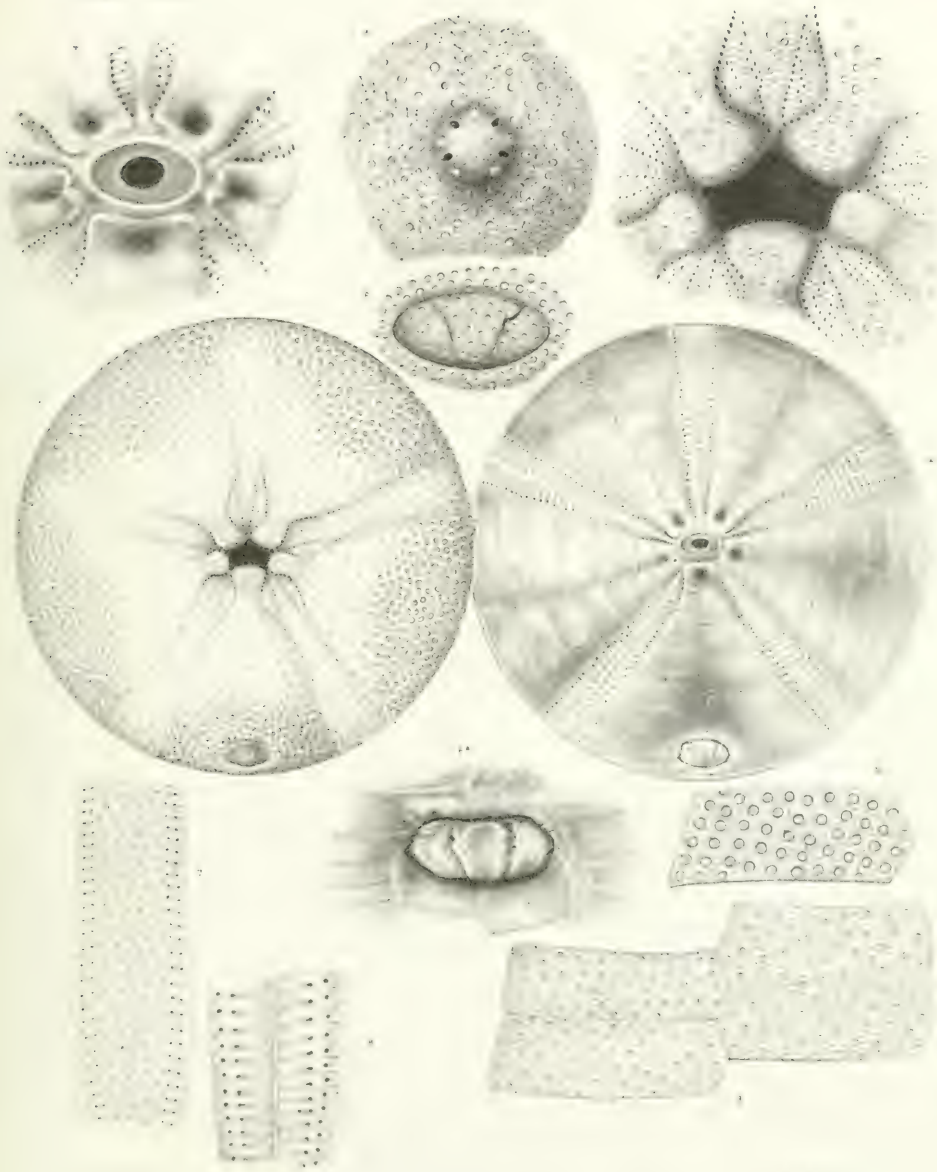

PLATE XVIII.

Paleopneustes hystrix A. Ag.

Fig. 1. Left half of test covered with spines, seen from above, natural size.
Fig. 2. Right half of test from above, denuded.
Fig. 3. Abactinal system ($\frac{2}{1}$).
Fig. 4. Same as Fig. 1, seen from actinal side, covered with spines.
Fig. 5. Same as Fig. 2, seen from actinal side, denuded.
Fig. 6. Actinostome ($\frac{2}{1}$), seen from actinal side.
Fig. 7. Same as Fig. 6, seen from the interior.
Fig. 8. Anal system ($\frac{2}{1}$).

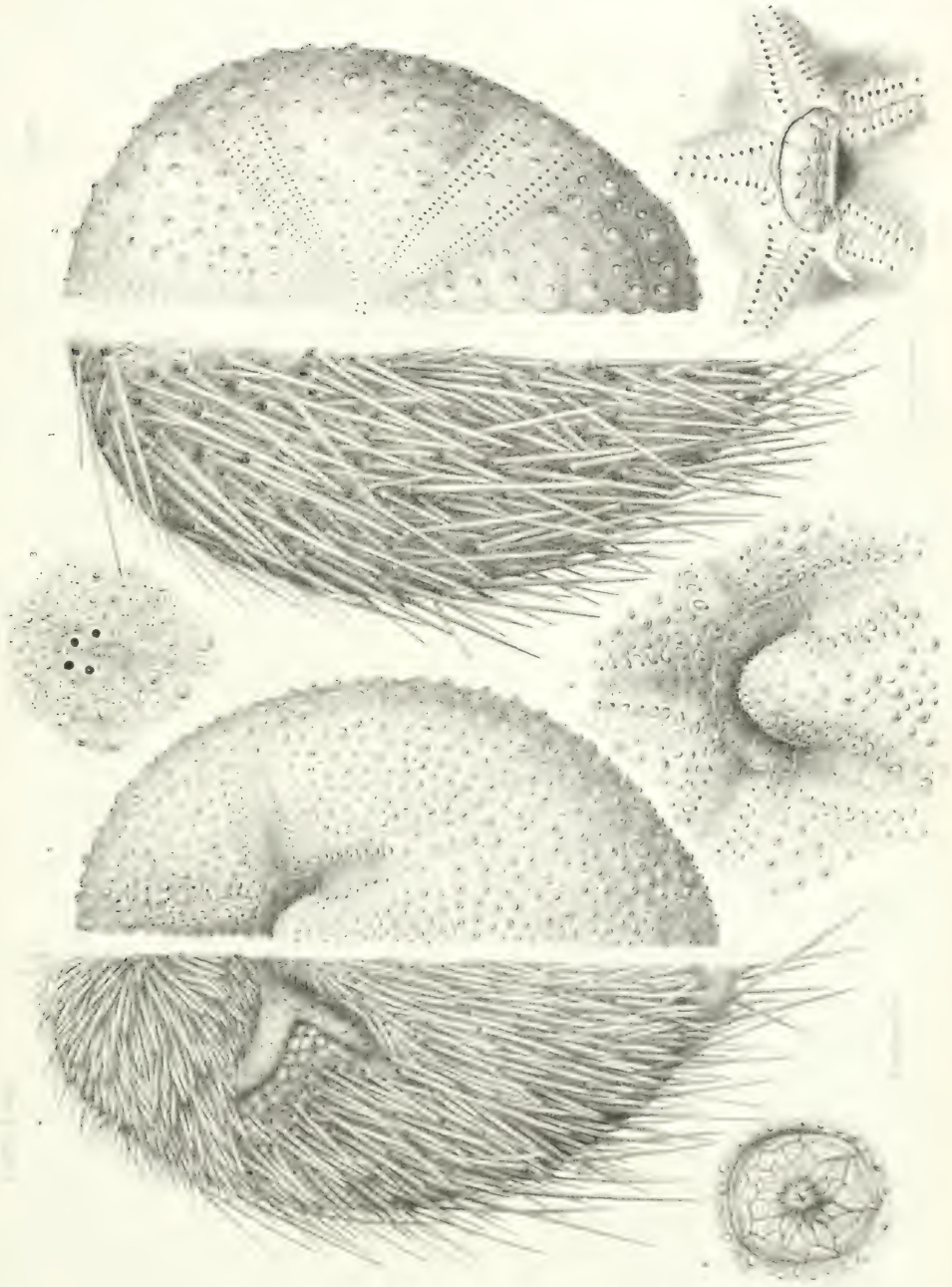

PLATE XIX.

Linopneustes longispinus A. Ag.

Fig. 1. Seen in profile (upper figure). Natural size.

Paleopneustes hystrix A. Ag.

Fig. 2. Seen in profile (lower figure). Natural size.

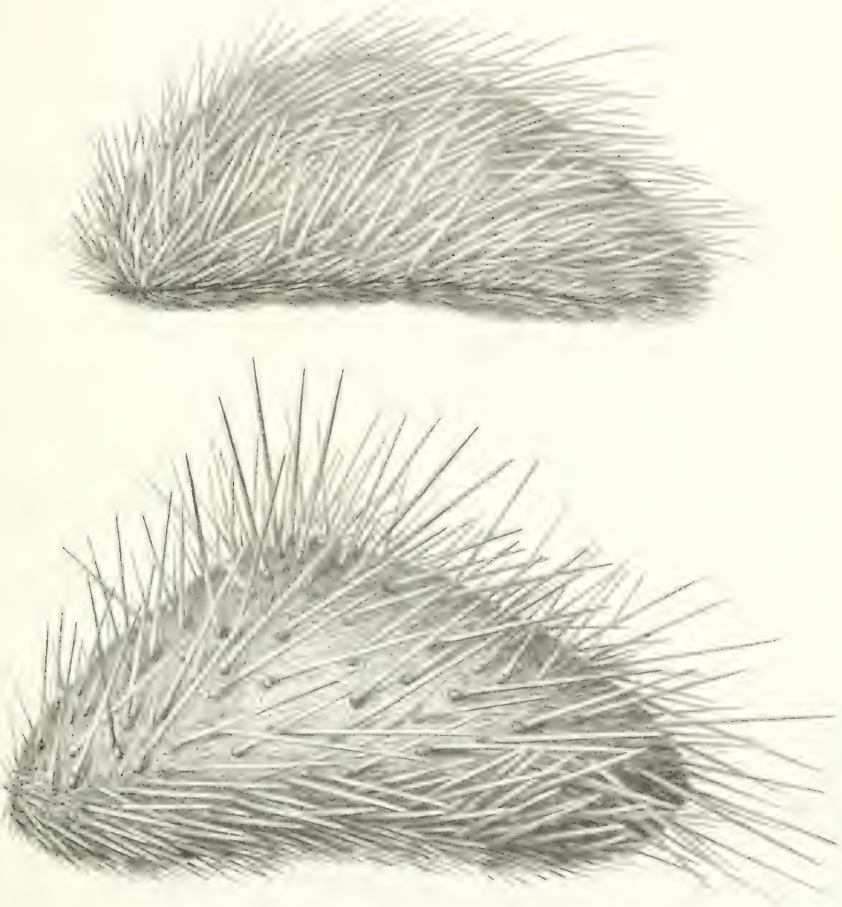

PLATE XX.

Linopneustes longispinus A. Ag.

Fig. 1. Right half of test covered with spines from above, natural size.
Fig. 2. Left half, denuded.
Fig. 3. Abactinal system ($\frac{3}{1}$).
Fig. 4. Same as Fig. 2, seen from the actinal side, covered with spines.
Fig. 5. Same as Fig. 1, seen from the actinal side, denuded.
Fig. 6. Actinal system ($\frac{3}{1}$).
Fig. 7. Anal system with subanal fasciole ($\frac{3}{1}$).
Fig. 8. Marginal fasciole on the edge of the ambitus.

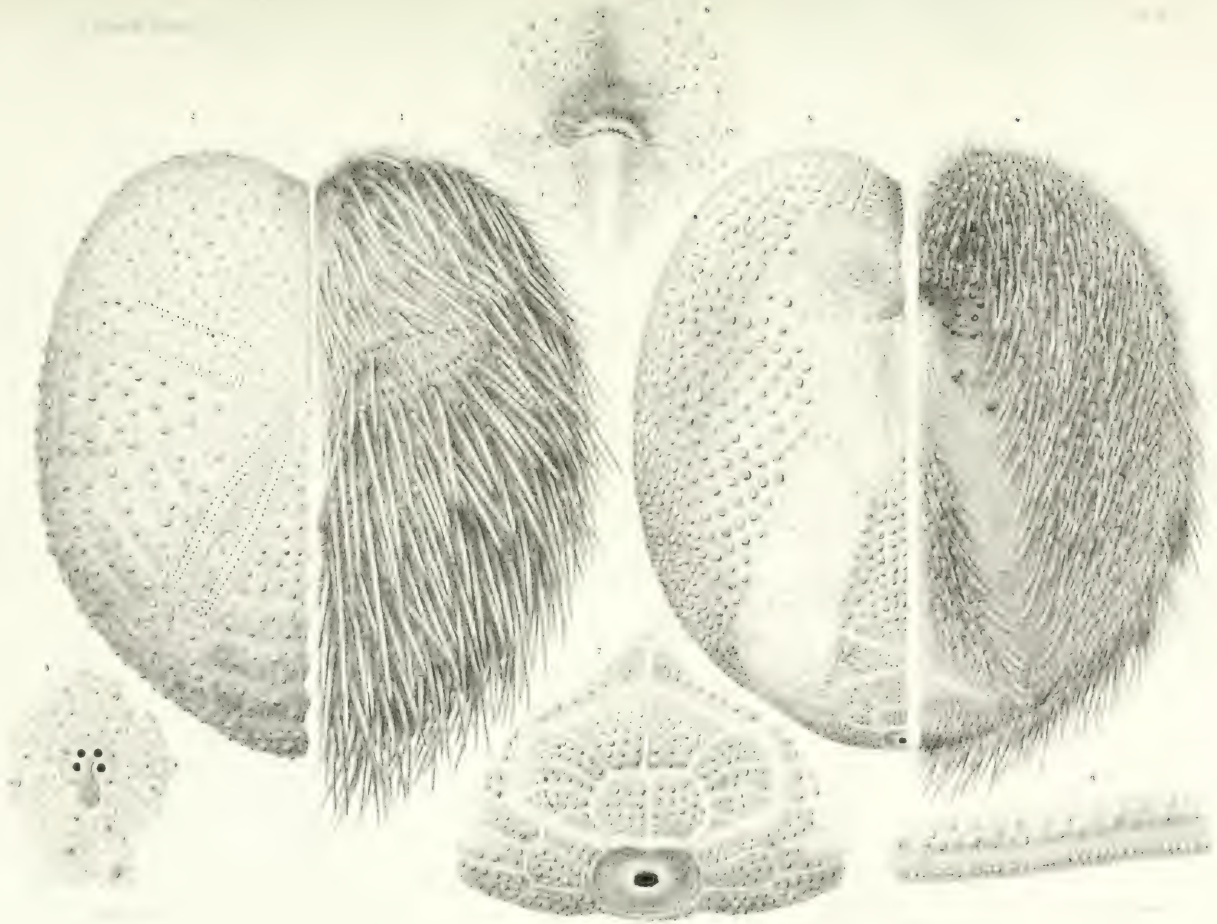

PLATE XXI.

Palæopneustes cristatus A. Ag.

Fig. 1. Lower extremity of the right anterior lateral ambulacrum of a specimen 150 mm. in length and 85 mm. in height ($\frac{1}{1}$).

Fig. 2. Part of test across the posterior part of the same ambulacrum at the ambitus ($\frac{1}{1}$).

Fig. 3. Apical system of same ($\frac{2}{1}$).

Fig. 4. Anal system of same ($\frac{1}{1}$).

Fig. 5. Actinostome of same ($\frac{1}{1}$).

Fig. 6. Part of test across the ambital region of the right anterior ambulacrum, to show part of the marginal fasciole of a specimen 85 mm. in length.

Fig. 7. Young *Palæopneustes cristatus*, seen in profile ($\frac{1}{1}$).

Fig. 8. Part of test (corresponding to Fig. 6) of same, magnified.

Fig. 9. Young *Palæopneustes cristatus* 16 mm. in length, seen from the abactinal side.

Fig. 10. The same as Fig. 9, seen in profile.

Fig. 11. The same, seen from the actinal side.

Fig. 12. Apical system of same, greatly magnified.

Fig. 13. Actinostome of same, greatly magnified.

Fig. 14. Anal system of same, greatly magnified.

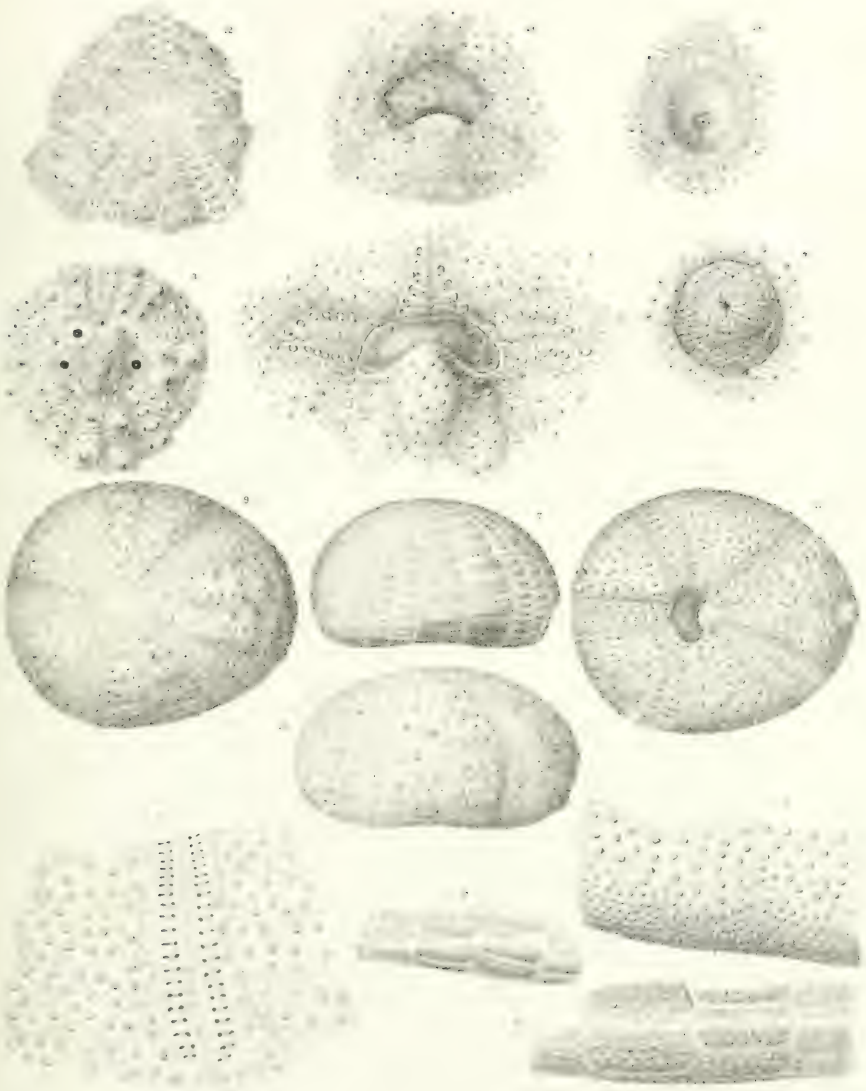

PLATE XXII.

Neolampas rostellata A. Ag.

Fig. 1. Specimen 11 mm. long. diameter, denuded, seen from the abactinal pole (female).
Fig. 2. The same as Fig. 1, seen from the actinal side.
Fig. 3. The same, seen in profile.
Fig. 4. The same, seen facing the anal extremity.
Fig. 5. The same, seen facing the odd anterior ambulacrum.
Fig. 6. Primary granulation of test of young specimen, 4 mm. long. diameter, arranged in indistinct irregular lozenge-shaped figures.
Fig. 7. Actinal termination of one of the lateral ambulacra, showing the five large, short-stemmed globular sphæridia placed in the median ambulacral space of a specimen 12 mm. long. diameter.
Fig. 8. Magnified view of denuded actinostome of a specimen 11 mm. long. diameter.
Fig. 9. Magnified view of actinal part of test, showing the suckers, sphæridia, and primary spines and tubercles of a specimen 6 mm. long. diameter.
Fig. 10. Abactinal part of test of a female, showing the manner in which the genital openings are protected by spines, of a specimen 12 mm. long. diameter.
Fig. 11. The same, denuded, showing the large genital openings and the pores of the madreporic body.
Fig. 12. General view of the abactinal system and adjoining part of the test of a female about 11 mm. long. diameter.
Fig. 13. Denuded specimen, seen from above (male), 9 mm. long. diameter.
Fig. 14. The same, seen in profile.
Fig. 15. The same, seen facing the (anal system) posterior extremity.
Fig. 16. The same, seen facing the odd anterior ambulacrum.
Fig. 17. Greatly enlarged view of the abactinal system and adjoining part of the test of the same specimen as Fig. 13.
Fig. 18. Greatly enlarged view of actinostome of same.
Fig. 19. Young male specimen, denuded, seen from the abactinal side, 4.5 mm. long. diameter.
Fig. 20. The same, seen in profile.
Fig. 21. The same, seen facing the posterior (anal) extremity.
Fig. 22. Enlarged view of anal groove of a specimen about 12 mm. long. diameter.
Fig. 23. Young specimen (measuring 2.5 mm. long. diam.) covered with spines, seen from the actinal side.
Fig. 24. The same, seen from the abactinal side.
Fig. 25. Plates of anal system.
Fig. 26. Head of short-stemmed trifid actinal ambulacral pedicellaria.
Fig. 27. Long-stemmed, long-headed trifid coronal pedicellaria.
Fig. 28. Young miliary spine, with spiny cupuliform extremity.
Fig. 29. Minute short-stemmed ellipsoidal sphæridia.
Fig. 30. Anal pyramid, composed of eight large triangular plates, of a young specimen 4 mm. long. diameter.

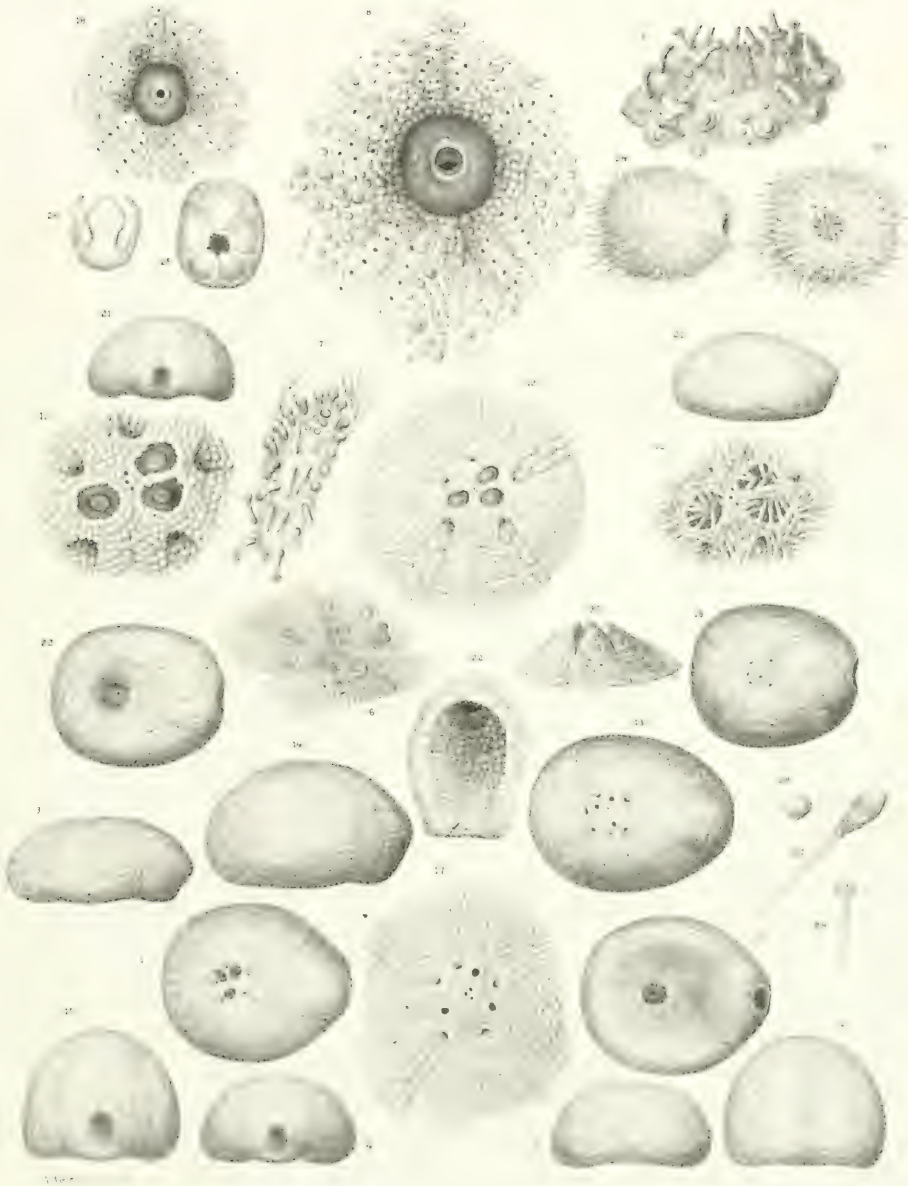

PLATE XXIII.

1–4. **Rhinobrissus micrasteroides** A. Ag.

Fig. 1. Seen in profile, covered with spines.
Fig. 2. Same, seen from the actinal side.
Fig. 3. Seen from above, denuded.
Fig. 4. Seen facing the posterior extremity.
Figs. 1–4 from a specimen 23 mm. in long. diameter.

5–14. **Palæotropus Josephinæ** Lovén.

Fig. 5. Seen from above, covered with spines.
Fig. 6. Same, seen from the actinal side.
Fig. 7. Denuded specimen, about the same size, seen from the abactinal side.
Fig. 8. Same, seen from the actinal side.
Fig. 9. Same, seen in profile.
Fig. 10. Same, seen from the anterior extremity.
Fig. 11. Same, seen from the anal extremity.
Fig. 12. Magnified view of abactinal system of same.
Fig. 13. Magnified view of anal system.
Fig. 14. Magnified view of actinal system.

PLATE XXIV.

1–5. **Echinolampas depressa** Gray.

Fig. 1. Young specimen, seen from above, 5 mm. long. diameter.
Fig. 2. The same, seen in profile.
Fig. 3. The same, seen from the actinal side.
Fig. 4. The actinostome of same.
Fig. 5. The anal system of same.

6–15. **Palæobrissus Hilgardi** A. Ag.

Fig. 6. Seen from above, covered with spines.
Fig. 7. The same, from the actinal side.
Fig. 8. The same, in profile.
Fig. 9. Same as Fig. 7, denuded.
Fig. 10. Same as Fig. 6, denuded.
Fig. 11. Same as Fig. 8, denuded.
Fig. 12. Same, seen facing the anal extremity. Figs. 6–12, natural size.
Fig. 13. Actinostome of Fig. 9, enlarged.
Fig. 14. Anal system, enlarged.
Fig. 15. Apical system, enlarged.

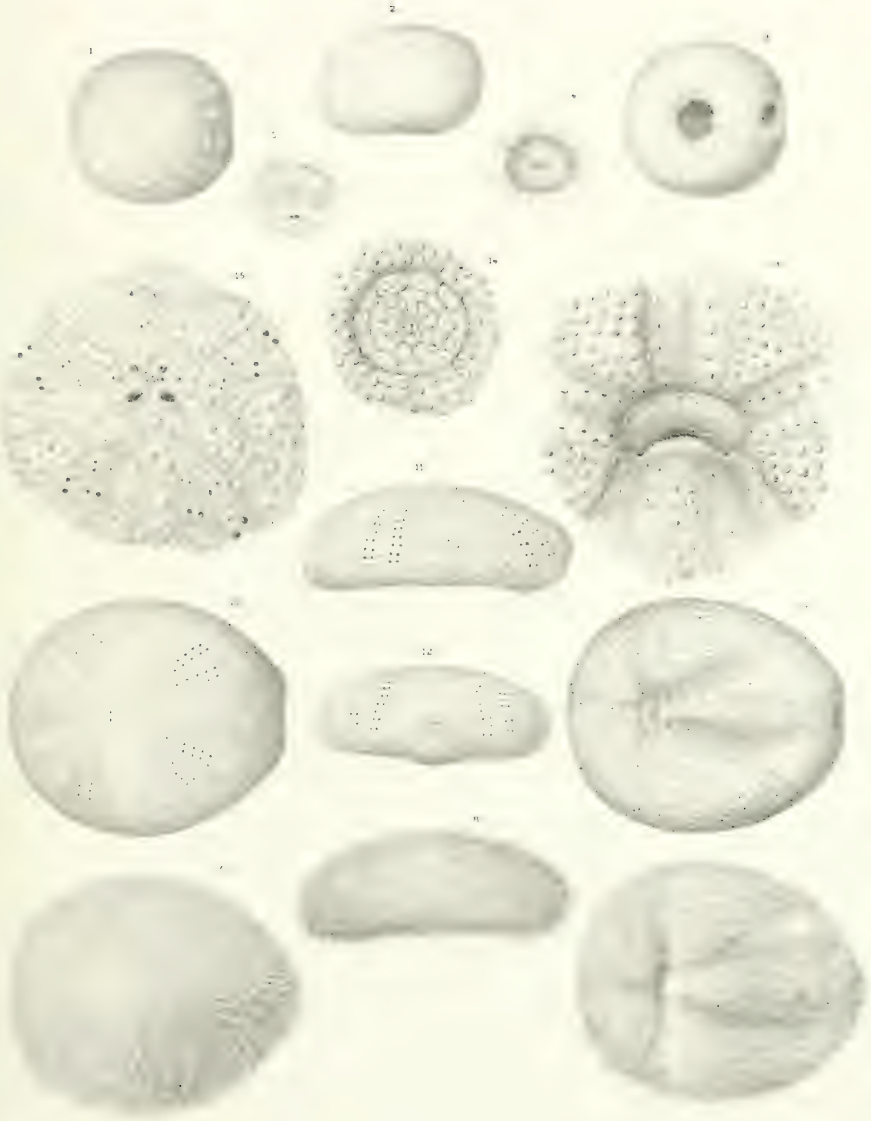

PLATE XXV.

Agassizia excentrica A. Ag.

Fig. 1. Seen in profile, covered with spines, 20 mm. long. diameter.
Fig. 2. A specimen of the same size, seen in profile, denuded.
Fig. 3. The same, seen from the actinal side.
Fig. 4. The same, seen from the abactinal side.
Fig. 5. The same, seen facing the odd anterior ambulacrum.
Fig. 6. The same, seen facing the anal system (posterior extremity).
Fig. 7. Young Agassizia, 7 mm. long. diameter, seen in profile.
Fig. 8. The same, seen facing the anal system.
Fig. 9. The same, from the abactinal pole.
Fig. 10. The same, seen from the actinal side.
Fig. 11. Enlarged abactinal system, with adjacent part of test of a small specimen 6.5 mm. long. diameter.
Fig. 12. Abactinal system of a young Agassizia, 3 mm. long. diameter.
Fig. 13. Actinal system of same.
Fig. 14. Magnified miliary spines of the lateral fasciole.
Fig. 15. One of the large ambulacral suckers of the odd anterior petaloid ambulacrum, expanded, from a specimen 11 mm. long. diameter.
Fig. 16. Four ambulacral suckers from same, of the outer petaloid part of the odd anterior ambulacrum, somewhat contracted.

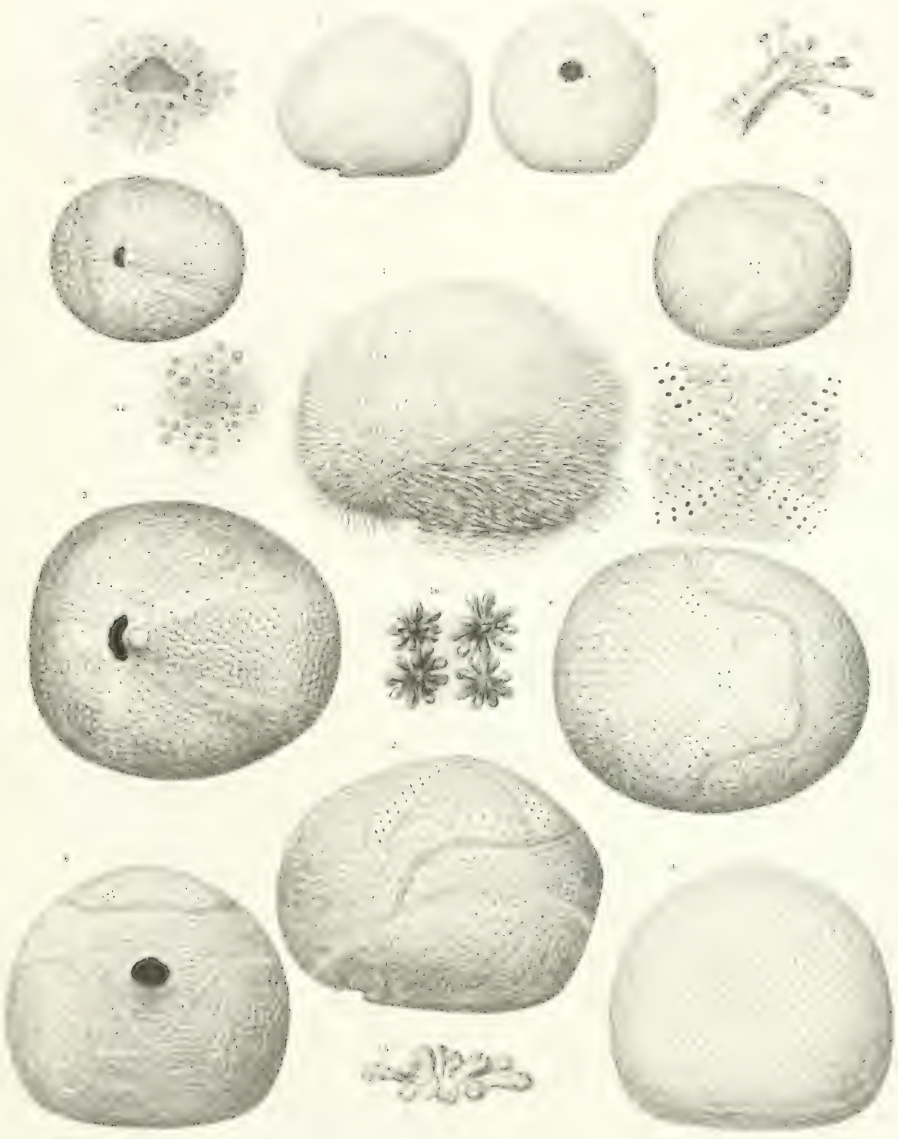

PLATE XXVI.

1–3. **Urechinus naresianus** A. Ag.

Fig. 1. Actinostome of specimen 33 mm. long. diameter.
Fig. 2. Abactinal system and adjoining part of test of same.
Fig. 3. Anal system and adjoining part of test of same.

4. **Rhinobrissus micrasteroides** A. Ag.

Fig. 4. Specimen 32 mm. long. diameter, seen from the abactinal side.

5, 6. **Schizaster (Periaster) limicola** A. Ag.

Fig. 5. Anal system of specimen 68 mm. long. diameter.
Fig. 6. Apical system, with surrounding part of test of same.

7–18. **Brissopsis lyrifera** Agass.

Fig. 7. Elongated type, seen from the abactinal side, natural size.
Fig. 8. The same, seen in profile.
Fig. 9. Enlarged view of posterior extremity of test, showing the anal system and fasciole, with the subanal fasciole.
Fig. 10. Portion of lateral interambulacral part of test near the ambitus.
Fig. 11. Portion of posterior lateral ambulacral zone.
Fig. 12. Portion of anterior lateral ambulacral zone.
Fig. 13. Globular type of the species, seen from the abactinal pole, natural size.
Fig. 14. The same, seen in profile.
Fig. 15. Posterior part of test of same, enlarged, corresponding to Fig. 9 in the elongated type.
Fig. 16. Corresponds to Fig. 10 of the elongated type.
Fig. 17. Corresponds to Fig. 11 of the elongated type.
Fig. 18. Corresponds to Fig. 12 of the elongated type.

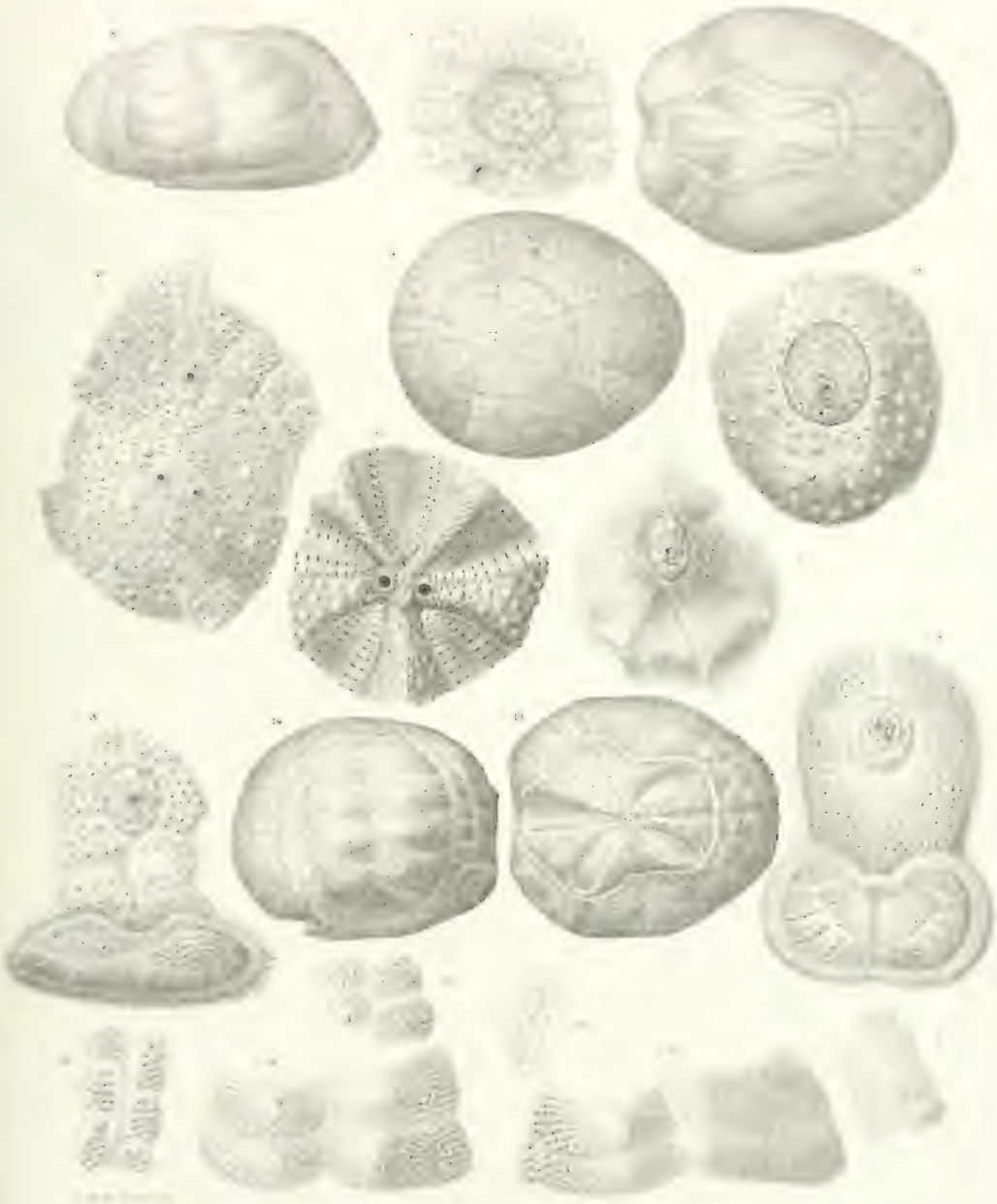

PLATE XXVII.

Macropneustes spatangoides A. Ag.

Fig. 1. Seen in profile, natural size.
Fig. 2. Another specimen, seen from the abactinal side, natural size.
Fig. 3. Enlarged view of actinostome of same.
Fig. 4. Enlarged view of the reticular peripetalous fasciole of the specimen of Fig. 2.
Fig. 5. Enlarged view of anal system and subanal fasciole of the same.
Fig. 6. Profile outline of a large specimen, with high posterior extremity, natural size.
Fig. 7 The same, seen from the abactinal pole ; the apical part of the petaloid ambulacra has become atrophied, as is so frequently the case in allied genera.

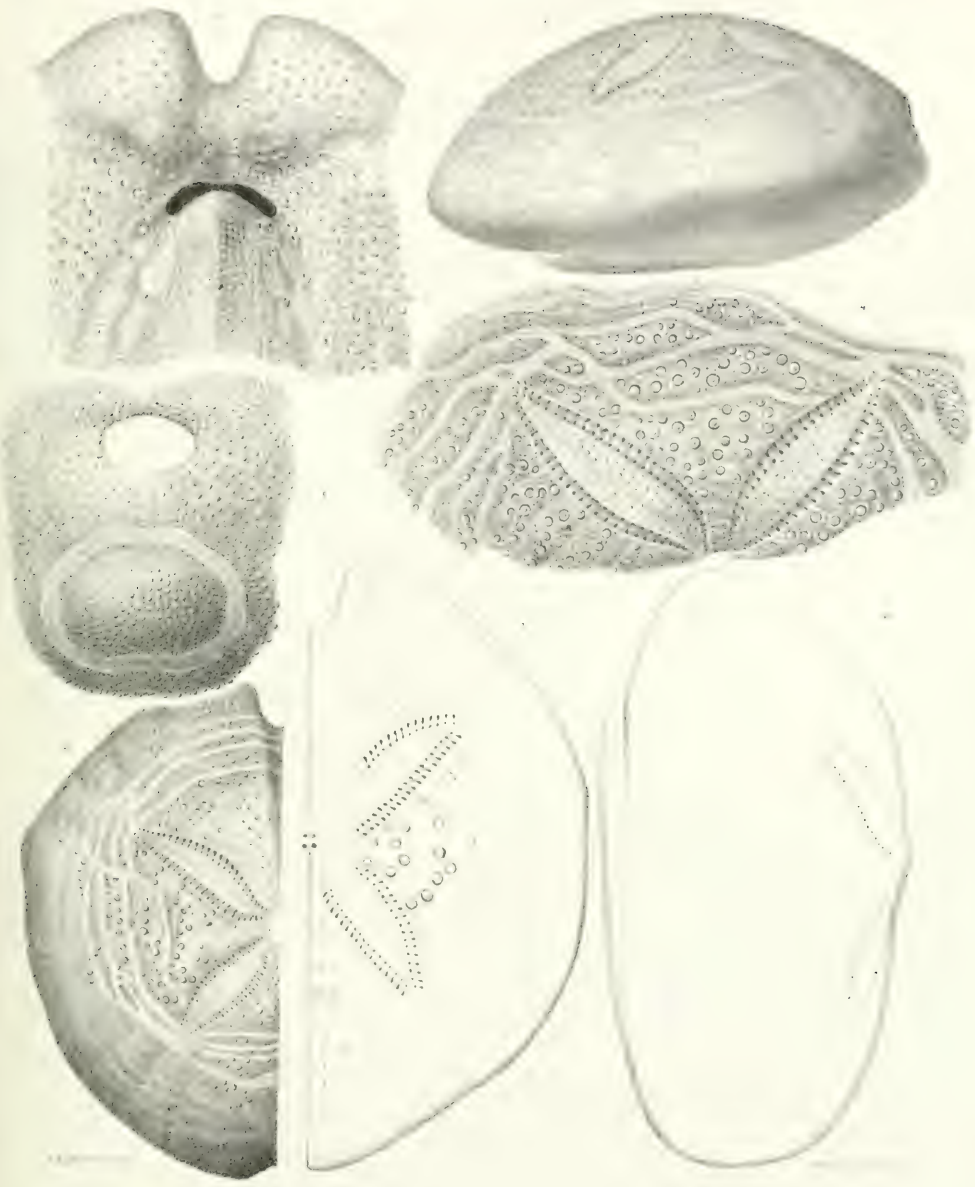

PLATE XXVIII.

1–7. **Schizaster orbignyanus** A. Ag.

Fig. 1. Denuded specimen, natural size, seen in profile.
Fig. 2. The same, seen from the abactinal pole.
Fig. 3. The same, seen from the actinal side.
Fig. 4. Anal system of subanal fasciole of same.
Fig. 5. Specimen covered with spines, natural size, seen from the abactinal side.
Fig. 6. Profile (natural size) of posterior extremity of a specimen intermediate between Figs. 1 and 5.
Fig. 7. Anal system of same, with subanal fasciole, somewhat enlarged.

8–14. **Schizaster fragilis** Agass.

Fig. 8. Young Schizaster, seen in profile, 23 mm. long. diameter.
Fig. 9. Anal system of same, enlarged.
Fig. 10. Somewhat younger Schizaster than Fig. 8, 10 mm. long. diameter, seen in profile.
Fig. 11. Anal system of same, with its subanal fasciole.
Fig. 12. Still younger specimen, only 6 mm. long. diameter, seen in profile.
Fig. 13. Anal system and adjoining part of test of same.
Fig. 14. Extremity of the petaloid right anterior ambulacral petal, with its adjoining fasciole, of a specimen about 55 mm. long. diameter.

15, 16. **Schizaster canaliferus** Agass.

Fig. 15. The extremity of the left petaloid ambulacrum of a specimen measuring 70 mm. long. diameter.
Fig. 16. The anal system and fasciole of same.

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AT HARVARD COLLEGE.

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ON AN EXTINCT TYPE OF DOG

FROM

ELY CAVE, LEE COUNTY, VIRGINIA.

By J. A. ALLEN.

PUBLISHED BY PERMISSION OF N. S. SHALER AND J. R. PROCTOR,
DIRECTORS OF THE KENTUCKY GEOLOGICAL SURVEY.

WITH THREE PLATES.

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December, 1885.

ON AN EXTINCT TYPE OF DOG FROM ELY CAVE, LEE COUNTY, VIRGINIA.

The five bones which form the subject of the present paper were found by Professor N. S. Shaler in Ely Cave, Virginia, close to the Kentucky line. They consist of a scapula, a humerus, a femur, and a tibia, all belonging to the right side, and a pelvis. A comparison of each singly with the corresponding bones of a dog or wolf shows at once their canine affinities; taken collectively, however, they indicate an animal of very different proportions from any of the ordinary wild *Canidæ*, or from any race of domestic dog. The bones were found together, and appear to have belonged to the same individual. As cave finds are sometimes open to suspicion, especially in the case of remains of animals from or near the surface of a cave floor, my first endeavor, on finding that these bones were not referable to any existing indigenous species, was to identify them with some small stout form of domestic dog; here, however, no nearer approach was found to the type in question than among the wild species. The conviction, therefore, that these bones represent an extinct type of the dog family has gradually become strengthened by the comparisons made until no other hypothesis seems tenable.

These bones differ from those of ordinary dogs, wild or domestic, in the shortness of the humerus as compared with the scapula, and of the femur as compared with the pelvis, but especially in the form of the pelvis, which is arched to a most remarkable degree, more so than in any other species known to me. Other details in which these bones differ from those of the fox, wolf, and dog are pointed out in the descriptions here following. As regards the relationship of the type in question with exotic or extinct forms, I can say little, being without means of making the necessary comparisons. In general form it was evidently a very short-limbed, heavy-bodied animal, recalling the proportions of the badger rather than those of a dog. For this reason it would be desirable to compare it with the short-legged *Icticyon venaticus* of South America; in lack, however, of the opportunity, I can only add that the descriptions of this animal do not lead one to expect even here a very close affinity. In regard to extinct species, of few only are the limb-

bones known. As regards those from North America, referred to *Canis* and allied genera, a comparison is needless, the differences are at once so obvious. With the Miocene genus *Amphicyon* there are some points of resemblance; both are stout, short-legged forms; and both lack the supracondylar foramen so characteristic of the ordinary dogs. The *Amphicyon vetus*, described by Dr. Leidy, from the bad lands of White river, Dakota, from parts of the skull and fragments of jaws, was evidently an animal of about the same size. From what is known of the cave fauna of the region in question, however, it seems hardly probable that the remains here described are referable to a Miocene genus. Unfortunately the skull, which would give a much better clue to the affinities of the beast, is lacking, although it is not improbable that it still exists, as well as many other parts of the skeleton, in the cave near the point where the bones here described were gathered.

Pachycyon, *gen. nov.*

Scapula equal in length to the humerus. Pelvis greatly arched, equal in length to the femur. Tibia a little shorter than the femur. Limb-bones remarkable for their thickness in comparison with their length.

Pachycyon robustus, *sp. nov.*

Scapula (pl. I, figs. 1—4).—The scapula, in comparison with this bone in the fox, coyote, wolf, and various races of the dog, presents, separately considered, several points of interest: (1.) The angle near the proximal end of the anterior border (see pl. I, fig. 1) is unusually strongly developed, and is placed much nearer the suprascapular border than in the animals named. (2.) The portion below the origin of the spine is much elongated, so that while the acromion process is well developed, it falls short of a plane parallel to the glenoid surface, instead of passing slightly beyond it, as in the coyote, dog, wolf, etc. This portion of the scapula is actually 1^{mm} longer than in the coyote, while the whole length of the scapula is one eighth less. (3.) The posterior border is strongly everted. This is in part due to the warping of the bone, as is shown by minute fractures; yet there is evidence of a considerable amount of normal eversion, much more than is usual in the *Canidæ*. With these exceptions, there is nothing in this bone by which it is especially distinguishable from the scapula of a dog of corresponding size, except possibly the greater depth of the spine. Taken, however, in connec-

tion with the humerus, it is remarkable for its length, which is to the humerus as 110 to 100. The same proportion in the fox is as 66 to 100; in the coyote as 74 to 100; in the wolf as 76 to 100; in the bull terrier and Newfoundland dog as respectively 80 to 100. The relative length of the scapula, compared to the humerus, is thus 30 per cent. greater than in one of the most thickly-set races of domestic dog (bull terrier), 35 per cent. greater than in the coyote and wolf, and 44 per cent. greater than in the fox. This proportion between scapula and humerus results not so much, however, from the lengthening of the scapula as from the excessive shortening of the humerus, which, like the femur and tibia, is very short and thick.

MEASUREMENTS OF THE SCAPULA.[a]

	Pachycyon robustus.	Common fox.	Bull terrier.	Coyote.	Common wolf.	Newfoundland dog.
Extreme length	95	74	100	116	169	168
Greatest breadth	53	44	51	61	86	84
Antero-posterior diameter of glenoid cavity	21	14	22	23	34	34
Transverse diameter of glenoid cavity	13	9	14	16	22	23
Greatest height of spine	17	10	17	19	. . .	26

[a] The measurements given in these tables are in millimetres.

HUMERUS (pl. II, figs. 1—6).—The humerus differs from this bone in the ordinary Canids in its much greater thickness in proportion to its length, in its stronger curvature, and in the supracondylar fossa being imperforate, the usual broad foramen at this point being solidly closed by a heavy plate of bone. All of the ridges and tuberosities are strongly developed; the front border of the head forms a heavy overhanging ridge, and the deltoid ridge terminates in a broad, strongly projecting process (pl. II, figs. 2—3). The absence of the supracondylar foramen, so characteristic of the family *Canidæ*, is especially noteworthy; but its value as a distinctive feature in the present species is lessened by the fact that it is sometimes partly, and in rare instances wholly, closed in old age in the domestic dog. It should be noted, however, that it is similarly absent in *Amphicyon*.

The following table of measurements of the humerus shows the relative dimensions of this bone not only in the present species, but in the fox, coyote, wolf, and in two widely different races of dogs. In respect to

thickness and other dimensions, except length, it will be noticed that there is a close agreement between the cave specimen and that of the bull terrier. In length, however, the latter exceeds the former in the ratio of 100 to 70, which, taken with the other dimensions, throws into strong light the exceeding shortness and stoutness of the humerus in the cave example:

MEASUREMENTS OF THE HUMERUS.

	Pachycyon robustus.	Common fox.	Bull terrier.	Coyote.	Common wolf.	Newfoundland dog.
Extreme length	87	112	126	157	210	205
Greatest antero-posterior diameter of proximal end	33	24	34	37	50	51
Greatest transverse diameter of proximal end	25	16	24	24	35	36
Greatest antero-posterior diameter of distal end	19	11	19	22	29	30
Greatest transverse diameter of distal end	12	10	14	14	21	21
Greatest antero-posterior diameter of shaft	23	19	30	30	40	44
Greatest circumference of shaft	48	31	54	58	76	77
Least circumference of shaft	33	25	38	38	53	56

PELVIS (pl. III).—The pelvis in the present species differs from that of ordinary *Canidæ* in only one important feature, namely, the high angle formed by the pre- and post-acetabular portions. In respect to the relative size of its different parts, and their individual contours, including even the ridges and tuberosities for muscular attachment, the differences are not greater, with possibly one exception, than obtains between different races of the domestic dog, or between different species of the genus *Canis*. The posterior portion of the ilium is narrower antero-posteriorly in relation to its more expanded anterior part than is the case with any of the other types with which it is here compared. Its truly remarkable feature is the high angle formed by the pre- and post-acetabular portions (pl. III, fig. 1), which gives to the pelvis as a whole a most peculiar and striking aspect. Placing the pelvis with the ventral surface upward, it is found that the ischiac axis, or a line passing through the tuberosity of the ischium and the center of the acetabulum, forms in the fox an angle with the plane of rest of 29°; in the coyote the same angle is 31°; in the wolf, 32°; in the bull terrier, 31°; in the Newfoundland dog 32°, from which it rises in the present species to 45°, or is nearly fifty per cent. greater than in the others. In respect to size, the pelvis is about one fifth shorter than that of the coyote, and about one tenth less in other dimensions.

MEASUREMENTS OF THE PELVIS.

	Pachycyon proastus.	Common fox	Bull terrier.	Coyote.	[illegible] wolf.	[illegible]
Extreme length	102	82	110	130	181	178
Greatest breadth (at ischyiac tuberosities)	75	61	83	87	123	132
Breadth at acetabula	62	44	67	65	96	100
Distance between innominate bones at posterior upper border of sacral surface	34	27	40	37	53	60
Distance between the most diverging points of the suprailiac borders (below)	60	45	81	68	98	122
Distance between the most convergent points of the suprailiac border (above)	43	34	67	56	60	61
Greatest breadth of innominate bone	36	24	37	40	59	61
Height at anterior end of pubic symphysis	40	26	35	41	57	62

FEMUR (pl. I, figs. 5—10).—The great trochanter rises slightly above the head of the femur, instead of being on a level with or slightly below it, as is usually the case in the *Canidæ*, and the lesser trochanter forms a very prominent conical point fully 2^{mm} in length. The well-marked ridge bounding the outer border of the head is situated on the median line of the shaft, and in line with the inner crest of the greater tuberosity. The cavity at the top of the shaft is thus nearly concealed when viewed from behind, while the head occupies one-half of the diameter of the shaft instead of one-fourth to one-third as in the dog, wolf, and fox (pl. I, fig. 5). The posterior surface of the proximal end of the shaft thus presents an appearance widely different from what ordinarily obtains in the *Canidæ*. The distal extremity descends obliquely, the trochlear portion having an extension posteriorly beyond the line of the posterior border of the shaft equal to nearly twice the antero-posterior diameter of the shaft, instead of merely equaling it as in the other forms with which the present species is here compared. The condyles are narrower and less widely separated by the intercondylar notch; the trochlear articular surface is also narrow, prolonged, and looks more directly forward. The shaft immediately above the condyles has its posterior face greatly expanded and deeply hollowed. In other respects the femur is noteworthy only for its shortness and consequent stoutness of form. This feature becomes a striking one when the femur is considered in relation to the pelvis, which it only barely equals in length instead of greatly exceeding. In the fox the ratio of the length of the pelvis to that of the femur is as 71 to 100; in the coyote, the bull terrier,

and Newfoundland dog, respectively, as 80 to 100; in the wolf as 83 to 100. In the species under consideration this ratio is as 100 to 100, or nearly the same as that of the scapula to the humerus. The femur is thus one-fifth to one-fourth shorter, as compared with the length of the pelvis, than in the ordinary *Canidæ*. As will be seen from the table of measurements, it most nearly agrees in size with that of the bull terrier, but is about one-third shorter.

MEASUREMENTS OF THE FEMUR.

	Pachycyon robustus.	Common fox.	Bull terrier.	Coyote.	Common wolf.	Newfoundland dog.
Extreme length	102	115	143	164	218	222
Transverse diameter of proximal end	27	23	30	39	50	49
Transverse diameter of distal end	25	20	28	29	39	40
Least circumference of shaft	33	25	37	39	54	54

TIBIA (pl. II, figs. 7—12).—The tibia, like the humerus, is noteworthy for its unusually high degree of curvature, and, like this latter and the femur, for its stoutness in proportion to its length. It differs, also, to a well-marked degree in the contours of its extremities, especially those of the distal end.

MEASUREMENTS OF THE TIBIA.

	Pachycyon robustus.	Common fox.	Bull terrier.	Coyote.	Common wolf.	Newfoundland dog.
Extreme length	99	129	142	177	222	223
Antero-posterior diameter of proximal end	30	23	31	36	47	50
Transverse diameter of proximal end	27	22	30	32	45	45
Antero-posterior diameter of distal end	14	10	14	15	17	17
Transverse diameter of distal end	18	15	20	20	30	30
Least circumference of shaft	32	23	33	33	48	50

ON THE AGE OF THE ELY CAVE.

The foregoing description of certain remains of canine animals which were found in Ely Cave, in Lee county, Virginia, require for their elucidation a general description of the geological conditions of this cavern. In 1877 the attention of my friend and colleague, Mr. Lucien Carr, Archæologist of the Kentucky Survey, was called to this cave on account of the quantity of human bones that were found in it. In the course of his explorations he came upon some small fragments of what seemed to be human Tibæ, the proportions of which were very surprising. On account of these discoveries I made a visit to this cavern, and spent a day in endeavoring to ascertain whether it would repay a careful excavation. The rocky condition of the floor, and other circumstances, made this seem undesirable. Unfortunately, my notes made on the ground have been lost, so that I have to give the following statement principally from memory, aided by the recollections of Mr. Carr, who spent some weeks in this neighborhood.

Some general statements concerning the geological structure of this district is necessary to a proper understanding of the conditions of this cavern. If the reader will consult a map of this district, he will perceive that its principal geographical features are the Cumberland Mountains on the west, a very continuous ridge of the Alleghanean type, that extends for over a hundred miles like a wall, and the mountain known as Wallen's Ridge on the east, and between them the valley of Powell's river. The whole section, from Wallen's Ridge on the east, across the valley of Powell's river, to the western side of Cumberland Mountains, constitutes a great anticlinal of very gentle curves. The caverns in this section are found either in the Subcarboniferous limestone or in the limestones of the Cambro-Silurian series. Those in the Subcarboniferous limestone are by far the larger; but as this part of the section is subject to a rather rapid erosion, they do not represent a very long duration of geological time. This Subcarboniferous series of limestones lie at the base of the Cumberland Mountains, and, with the overlying millstone grit, forms the greater part of the eastward wall of that ridge. Beneath them is the Devonian black shale, the Ohio shale of this Survey. This last named deposit consists of very soft bituminous clays, arranged in shaly layers. Frost or running water, aided by the capilarity of these closely adjoined layers, rapidly decomposes this shale

into a fine clay that is easily borne away by the streams that run at the foot of the mountain. In this way the Cumberland escarpment has been forced to make a very rapid retreat from the middle of the great anticlinal, in which lies Powell's river, back to its present position. The total amount of its retreat since the elevation of the Powell anticlinal, which probably took place in the Triassic time, is not less than five, and may be as much as seven miles. As the caves do not extend more than two or three hundred feet back from the face of the escarpment, it is evident that they cannot represent a very great lapse of geologic time. I do not believe that the present series of caverns in this escarpment have endured more than *about* one hundredth part of the time occupied in the retreat of the escarpment from the centre of the Powell anticlinal. Estimating the duration of time since the Triassic period at from thirty to forty millions of years, the caverns now lying in the bed of the Subcarboniferous limestone cannot have been in existence for more than about three to four hundred thousand years. Owing to the peculiar position of these escarpment caverns, there is little chance that the waste arising from the destruction of one set of caverns can be carried into another successive set of caves, as is the case in many other regions. These considerations make it clear that a very great geological age cannot well be represented in these caves of the Subcarboniferous series.

The other series of caves in this region, the series to which the Ely cave belongs, are very differently conditioned. They do not lie in vertical escarpments, but upon the surface of a broad field of limestones, which have a structure eminently adapted to favor the preservation of caves. These limestones are of the Cambro-Silurian age, corresponding approximately in geological position to the series of rocks elsewhere called the Cincinnati group. These beds represent a thickness of over a thousand feet of limestones, which are, in the main, of the ordinary carbonate of lime, but contain many thick beds of a dolomitic nature. These dolomitic layers here, as everywhere, afford stout barriers to erosion. Water works its way through joints in their layers into the more erodable beds below, and there excavates broad, flat caverns, which extend their arches until the roof becomes too wide to support itself, when the cavern is opened to the day. These layers of dolomitic limestone prevent any rapid ablation of the surface they cover, so that, while the face of the escarpment in which the caverns of the Subcarboniferous limestone are found has retreated

about thirty to forty thousand feet, these lower deposits have not lost more than about five to eight hundred feet of their depth. The result is that this set of caverns remain far longer in existence than do those in the Subcarboniferous limestone. I am inclined to believe that one of these caverns in the high-lying ridges of Powell's Valley may be five or ten times as ancient as those in the Subcarboniferous escarpment; they may perhaps date their origin back to the early part of the Pliocene time.

It is clear that the cave in which the bones before described were found is one of the oldest of these very ancient caverns. It is well elevated above the present drainage level of the country, lying upon one of the flat-topped ridges which rise from one to two hundred feet above the small spurs that intersect the ground. It is near the top of the ridge, a position that indicates that it is very ancient. The streams that must have cut it out are now seen in channels far below its level and horizontally far away.

The cave is not conveniently placed for the use of even primitive man. The entrances are by difficult and rather blocked-up ways. The space within is not large, there being only a few hundred feet of narrow and rather damp chambers. During the civil war it was used as a place of storage for valuables and for concealment of small bands of partisans during the various raids made through this country by the two armies. In this occupation the remains of Indians, which had been plentifully deposited here, had been much dragged about in the vague searching of various persons. We did very little digging in the cavern, in no case going more than a foot or two below the surface of the earth. There seemed to be no considerable amount of stalactite matter on the floor of the cavern, the insoluble nature of the overlying rocks not favoring the formation of such deposits. The bones described in Mr. Allen's memoir were obtained somewhere in the course of these slight excavations. At the time I paid no attention to them, supposing that they belonged to some of the ordinary cavern dwelling animals of the country, so that I am unable to state just whereabouts in the cavern they were found. The whole search did not occupy more than half a day's time, and many of the low, tortuous passages of the cavern were left quite untouched. I am disposed to believe that a careful search of this cavern will be likely to disclose the other bones of the interesting creature described in the monograph of Mr. Allen.

For many years I have been carefully observing our American cavernous districts, with a view to determining the points most likely to afford good places for exploration. I am inclined to believe that the caves of this district are more likely to furnish important paleontological data than those of any other region known to me. The reasons for this belief are as follows:

In the first place, the very extensive caves in the Subcarboniferous escarpment are peculiarly well fitted for the use of the primitive races of men who may have inhabited this country. They are well placed for the purposes of refuge, being easily defensible, and abounding in water. The region near these springs was rich in game and fish, and well fitted for agriculture. It still abounds in the remains of its aboriginal peoples. If our American caves were ever extensively used by the primitive peoples of the country, evidence of such occupation will surely be found here.

The caves in the Cambro-Silurian series, on which the Ely cave lies, are not so well placed for human use as those in the Subcarboniferous escarpment, yet, as we have seen, they are found under conditions that favor their preservation for far longer periods of time. They are often found under conditions such as to make it certain of their having come down from times so remote that we may fairly hope to find within them fossils of the Pliocene age. All this region abounds in this class of caves, and among them are many which, occupying the hill-tops at points of several hundred feet above the present level of the streams, are certainly far more ancient than the beginning of the last glacial period.

This valley of the upper Tennessee lies in the southernmost part of the region that was occupied by the glaciers of the last ice time. The edge of the great ice-field came down to near the Ohio in the country one hundred miles to the north, and local glaciers occupied the higher districts in the North Carolina Mountains, hills that are within sight of this valley. Here must have flourished the remarkable fauna that occupied the regions near this ice sheet, and here, if anywhere, we may hope to find the remains of man associated with extinct groups of animals.

The great extent of this cavernous district is also a very advantageous feature for the naturalist's work. Between the head waters of the Tennessee river system in southwestern Virginia and the neighborhood of Chattanooga, over an east and west width of about sixty miles, there are some thousands of these caverns; so that the explorer will have an abundant

chance to so select his places of exploration as to secure caverns of recent or very ancient date, according to the end he has in view. I know no other part of the United States that is so favorably placed for this class of inquiries.

N. S. SHALER.

EXPLANATION OF PLATE I.

Pachycyon robustus. (All the figures are of natural size.)

Fig. 1. Right scapula, external surface.
Fig. 2. The same, internal surface.
Fig. 3. The same, anterior view.
Fig. 4. The same, posterior view.
Fig. 5. Right femur, posterior view.
Fig. 6. The same, anterior view.
Fig. 7. The same, internal surface.
Fig. 8. The same, external surface.
Fig. 9. The same, proximal end, seen from above.
Fig. 10. The same, distal end, seen from below.

PACHYCYON ROBUSTUS

EXPLANATION OF PLATE II.

Pachycyon robustus. (All the figures are of natural size.)

Fig. 1. Right humerus, external surface.
Fig. 2. The same, internal surface.
Fig. 3. The same, anterior surface.
Fig. 4. The same, posterior surface.
Fig. 5. The same, proximal end, from above.
Fig. 6. The same, distal end, from below.
Fig. 7. Right tibia, anterior surface.
Fig. 8. The same, posterior surface.
Fig. 9. The same, external surface.
Fig. 10. The same, internal surface.
Fig. 11. The same, proximal end, from above.
Fig. 12. The same, distal end, from below.

PACHYCYON ROBUSTUS

EXPLANATION OF PLATE III.

Pachycyon robustus. (All of the figures are of natural size.)

Fig. 1. Pelvis, external surface.

Fig. 2. The same, ventral surface, direct view of ischiopubic portion.

Fig. 3. The same, ventral surface, direct view of iliac portion.

Fig. 4. The same, dorsal view.

Pachycynon robustus.

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RESULTS

OF AN EXAMINATION OF

SYRIAN MOLLUSCAN FOSSILS,

CHIEFLY FROM THE RANGE OF MOUNT LEBANON.

By CHARLES E. HAMLIN.

WITH SIX PLATES.

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INTRODUCTION.

By the favor of Rev. Selah Merrill, D.D., during the years 1875–77 Archæologist of the American Palestine Exploration Society, and now United States Consul at Jerusalem, the Museum of Comparative Zoölogy has recently become possessed of two small collections of Syrian molluscan fossils, chiefly from the range of Mount Lebanon. The one was made by Dr. Merrill himself, while prosecuting his work of exploration; the other, by Mrs. Bird, wife of Rev. William Bird, a missionary of the American Board of Commissioners for Foreign Missions, who with his family has been for many years stationed at Abeih, fifteen miles southeast of Beirût and among the mountains. As a large proportion of these fossils belong to species hitherto undescribed, and as others, of species already named, are better specimens of the same than those which were the basis of the original figures and descriptions, it has seemed desirable that the collections should be studied, and the results of the examination published.

Among the stores of the Museum of Comparative Zoölogy, a third small collection of fossil shells has been found, which is understood to be from "Lebanon," and to have been forwarded, perhaps presented, in 1866, by Rev. W. M. Thomson, D.D., author of the well-known work, "The Land and the Book," — for more than thirty years missionary in Syria, and at the date specified acting United States Consul at Beirût. The material for investigation thus furnished has been increased, through the kindness of the officers of the Congregational House in Boston, by the loan of some interesting specimens, labelled "Mount Lebanon," which are preserved in the Museum of the American Board.

Unfortunately, however, as is usual with collections made by other than experienced or professional hands, notes are wanting of the exact localities with a few exceptions, and of the nature and position of the strata without exception, from which the fossils of the several lots were taken. This deficiency renders it necessary to state here how far the localities represented by the different collections can be identified.

Dr. Merrill's collection was put into my hands by himself, bearing labels to distinguish specimens found at points outside of the district where the greater part were procured, and for the rest a written statement was made, at my request, that "almost all the

specimens came from the vicinity of Beirût, Abeih, Dog River (Nahr el Kelb) a few miles north of Beirût, and the mountains between this river and the Cedars, a mountainous district which extends more than twenty and not over thirty miles north and south, with Beirût and Dog River as a centre." To this portion of country I shall refer for convenience, in the following pages, as the Beirût district.

The Bird collection was received also from Dr. Merrill in person, with the oral statement that, as he understood, it was gathered at Abeih and in its vicinity. The fact that some of the shells are of species already recorded as from that locality, and that the rock material which makes up the fossils, adheres to them, or fills their interiors, is such as is known to characterize the richly fossiliferous strata of Abeih, constitutes strong internal evidence that most of the specimens are actually from the place from which they are said to come. Yet under the title Jurassic Ammonites (pages 9, 10) reasons are given for the conclusion that the three species from the Bird collection there named could not have come from Abeih, where only Cretaceous strata are known to occur, but must have been taken from beds older than the Cretaceous, such as in all Syria, so far as at present traced, are restricted to one narrow area, lying entirely without the circle of Beirût, and upon the slope of Mount Hermon.

Of the Thomson and Congregational House collections it can only be affirmed that they are from "Lebanon," but the testimony of the specimens themselves goes to make it very highly probable that all of them had their origin within what we have termed the Beirût district.

Of the fossils brought together from these different sources, as in the case of all other collections from the same region of which any accounts have been published, it is mainly the Gasteropods that have been preserved in any considerable degree of completeness. Such specimens characterize the Bird collection, made up principally of choice things selected apparently under the guidance of a taste which rejected whatever was displeasing to the eye. But of the greater number of Lamellibranchs, interior casts alone occur; and taking into account the like condition of things in other collections from the same strata, and the nature of the beds in which they are enclosed, the probability seems very small that of certain genera better representatives will ever be discovered.

In dealing with such specimens, one is at once confronted with the question how far it is useful — not to say *allowable* — to attempt the description of species from well-preserved casts which bear positive generic characters, but exhibit few of the superficial markings upon which the distinctions of species largely depend. While settling for himself this question, the student is likely to remember the censure which has been unsparingly visited upon several eminent palæontologists for presuming to confer specific names upon casts denuded of their tests, nor will he forget that later investigation has in signal instances justified their action.

The question is, perhaps, one of more interest in the study of molluscan fossils of the Cretaceous period, than with reference to those of any other. For while, for example, in determining the Cretaceous shells of Southern India and those of California and the Upper

Missouri country, Stoliczka in the first case, and Meek and Gabb in the others, had sufficient supplies of excellent material, able investigators have not seldom been reduced to the alternative of drawing conclusions from bad material, or of reaching no conclusions at all. This consideration, it seems to us, has not had due weight in forming the verdict which has been pronounced upon the work of Conrad as the first describer of Syrian fossil shells in any considerable number. The collections of the Lynch Palestine Expedition, and the other material which fell into Conrad's hands, were of very inferior quality; and if he were to name species, he was compelled to found them upon imperfect specimens, for he seems to have had no others. It was his further misfortune that the descriptions published in the Official Report of the expedition are meagre beyond the habit of their author, and that his figures, through fault of the artist, were poorly executed. From these several causes has resulted uncertainty concerning the identity of some of his species, and respecting the validity of others.

The Swiss Cretaceous Mollusca, described by Pictet and Campiche, afford a case not unlike that with which Conrad had to deal. These authors have been justly criticised for naming from casts so many species of the *Veneridæ*, a family in which the shells have often at the beaks and margins such thickness that it is impossible from the cast to reconstruct the exterior. But familiarity with the large Campiche collection (now in the Museum of Comparative Zoölogy) of molluscan fossils from the Cretaceous of Sainte-Croix, in which scores of specimens of the same species are but repetitions of like defective casts, obliges me to think that, if species are to be discriminated in the fossils of that locality, it must be by means of imperfect casts, for, with few exceptions, better examples are unknown.

Again, in his *Études Critiques sur les Mollusques Fossiles*, — *Monographie des Myes*, — the late Professor Agassiz instituted, chiefly upon the basis of naked casts taken from the Swiss Cretaceous strata, a series of new genera and species, of which the major part has stood the test of later discovery and criticism. That distinguished observer saw that in the family of *Myidæ* as limited by him (since in large part transferred to the *Pholadomyidæ* and *Anatinidæ*) the casts of his new genera indicated unmistakably that the shell must have been very thin, and that it was safe from the casts to infer the superficial character of the shells themselves, and that "those features, which are included in the terms *general figure and ornaments of surface*, acquire in the *Myidæ* [so limited] an increased degree of importance from their invariable persistence and distinctness of design, in a similar ratio that the hinges and their characters have degenerated in value." (Morris and Lycett, Mollusca from the Great Oölite, Part II, p. 99.)

So too among Gasteropods, by the introduction of the genus *Tylostoma* Sharpe relieved that of *Natica* from a burden impossible longer to be borne, and to-day are accepted as valid, not only the genus, but the species, which he founded thirty-five years since on no other basis than casts from the Cretaceous strata of Portugal, of which he says: "Few of the specimens found retain any portion of the shell, and in no instance was I fortunate enough to find a shell perfectly preserved, so that the specific descriptions are necessarily

imperfect." (Quarterly Journal of the Geological Society of London, V, p. 376, 1849.) And, in general, where better material cannot be obtained, if species are named with proper care and discrimination from casts distinctly recognizable as to their genera, well preserved, and possessing some striking and characteristic features, due regard being had to the nature of the test in the group to which they belong, it would seem that such species may be useful in studying the relations of the different beds in which they occur.

The foregoing remarks, however, have been suggested by general considerations more than by the demands of the work here recorded, as will appear from the following statement. Of the fossils subjected to examination, the most obscure casts, Gasteropods as well as Lamellibranchs, whose generic relations cannot be affirmed with certainty, are passed over without notice, except two species which are simply figured and referred to as indeterminate. Fourteen species of Gasteropods are described as new, of which all the specimens used for the descriptions and figures, retain the shell, and generally in satisfactory condition. Of sixteen new Lamellibranchs, ten species are described and figured from specimens bearing the shell, and of the other six, based upon casts, three are species of the thin-shelled *Pholadomyidæ* and *Anatinidæ*, and concerning only one of the three remaining can there be any doubt, if specimens of the species shall be found hereafter with the test preserved, that both shell and cast can be readily identified as of the same species, thus involving neither confusion nor unnecessary change in specific names. We have to regret the disadvantage under which we have labored, — shared with many predecessors in palæontological study, — of having been obliged in some instances to describe a species from a solitary example.

Age of the Strata from which the Fossils were derived.

Botta's *Observations sur le Liban et l'Antiliban*, published in 1833 (Mémoires de la Société Géologique de France, I, pp. 135–160), give the results of the first geological exploration of the region to which they relate. The sections in detail, and the geological plan, which accompany this excellent memoir, are still regarded as giving a correct idea of the actual succession of formations in the mountain chains. But concerning the age of those formations a change of opinion has followed upon later investigations. The rocks and fossils collected by Botta were submitted to Ami Boué, a learned geologist of his time and secretary of the Geological Society of France. Having made a comparative study of the specimens, with the aid of European collections, Boué came to the conclusion that the three *terrains* of Lebanon recognized by Botta correspond to the Upper Jurassic, the Greensand, and the Lower Chalk of European systems.

In 1837 Heinrich von Schubert and Professor Roth visited Palestine, made a great number of geological observations, and described various fossil beds in the Lebanon and Anti-Lebanon ranges. Roth took back with him to Germany many fossils. About the same time Russegger, an Austrian Councillor of Mines, made extensive journeys in Egypt, the Soudan, and Syria, including Lebanon and Anti-Lebanon. His opinions for a time were widely adopted, but were afterward discarded, and call for no further notice.

In 1848 occurred the "United States Expedition to Explore the Dead Sea and the River Jordan," of which the Official Report by the commander of the expedition, Lieutenant Lynch, was published in 1852. This report includes that of Dr. Anderson upon the Geology, and that of Mr. Conrad upon the Palæontology, of the parts explored. Besides the shells collected by the expedition, Conrad described some others from the same region which were furnished by individuals. He made by far the larger number to be Jurassic forms, and the rest Cretaceous. His determinations are considered as having misled Dr. Anderson in his decisions upon the geology of the country.

In 1864 the Duc de Luynes accomplished his Geological Exploration of the Dead Sea, accompanied by Louis Lartet as geologist, who during the next two years published his observations in several papers, printed in the Bulletin de la Société Géologique and the Comptes Rendus; and from 1869–72 appeared in the Annales des Sciences Géologiques his *Essai sur la Géologie de la Palestine et des Contrées avoisinantes.* There followed, in 1875, a folio volume, which includes his earlier memoirs, revised and enlarged. In the chapter devoted to the Palæontology of the Cretaceous formation is a list of molluscan fossils previously known from Palestine and Lebanon, and several new species are described and figured.

In 1867 Professor Oscar Fraas, of Stuttgart, published an important work, being Part I of his Aus dem Orient, the record of geological observations made by him in Egypt, the Sinaitic peninsula, and the environs of Jerusalem. In 1877 his *Juraschichten am Hermon* was issued, in the Jahrbuch für Mineralogie, etc., pp. 17–30, and the next year *Geologische Beobachtungen am Libanon,* or Part II of Aus dem Orient. The two parts taken together supply a full catalogue of all molluscan fossils known from Syria up to 1878, including, besides Conrad's recognizable species, European species of Lamarck, Sowerby, d'Orbigny, and others, as well as a considerable number described by Fraas himself. That part of the list found in Part I had been quoted in Lartet's folio of 1875. On comparing the lists of Conrad, Lartet, and Fraas, it will be seen that the number of new species from Syria, published since the date of Conrad's report, is not large. Of those described by Fraas, sometimes too briefly for ready identification, only very few seem to have been figured.

The most important consequence of the labors of Lartet and Fraas is the change of view which they have brought about with respect to the age of the stratified rocks of Palestine and the Lebanon region. It is now an established fact, that the great Cretaceous system which, stretching in Northern Africa through Morocco and thence eastward to Egypt, and southward into the Sahara and the Libyan Desert, crosses over into the peninsula of Sinai, spreads also over the greater part of Palestine and the ranges of Lebanon and Anti-Lebanon, and probably prevails east of the Jordan and the Dead Sea, in Gilead, Moab, and Idumæa. The earlier explorers seem to have been misled by the strong external resemblance of the light-colored limestones which they observed in Palestine to the rocks of the White Jura of Europe, and therefore regarded them as Jurassic.

In all Palestine proper, the Lebanon range, Cœle-Syria (the Bûkaa), and the Jordan valley southward to Akabah, there had been found up to 1878, upon the authority of

Fraas, no trace of any stratified rocks older than the Cretaceous formation. The *Geologische Skizze einer Reise durch Palästina und das Libanongebiet** of Professor G. vom Rath, published in 1881, makes good to that date the above statement of Fraas. But at Mejdel esh Shems, a village situated at an elevation of 1,340 meters upon the southeasterly slope of Mount Hermon, — the southern extremity of Anti-Lebanon, — Rev. Edwin R. Lewis, late Professor of Chemistry and Geology in the Syrian Protestant College at Beirût, discovered and identified what Fraas styles a mere "strip" or "patch" (*fleck*) of true Jurassic strata. Of this remarkable exposure of steeply tilted beds, interposed between Cretaceous rocks, one layer, a light-colored, efflorescent calcareous marl, extends upwards, forming the highest point of Mount Hermon, where Professor Lewis collected specimens of *Rhynchonella lacunosa* Schlotheim sp., a characteristic fossil of the Oxford Clay in Germany and France, and found at the lower level of Mejdel esh Shems in countless numbers. The layer of most importance in connection with the collections here considered is a "gray-black clay," a meter and a half thick, which imbeds the Jurassic Ammonites presently to be noticed, — species before known from the Ornati Clay of the uppermost Brown Jura of Europe. It seems altogether probable that more detailed exploration of this highly interesting district will reveal other outcrops of Jurassic strata.

The publications of Professor Fraas have been our only means of fixing with any degree of certainty the stratigraphic position of the various species enumerated in the following pages. That distinguished geologist in his earlier journey satisfied himself that the whole line from Jaffa to the Dead Sea passes over strata which belong to the Turonian and Senonian stages of the Upper Cretaceous, in this respect confirming the previously formed conclusion of Lartet. The Cretaceous strata of Lebanon are divided by Fraas into nine stages, or zones, as follows: —

1. The Glandarius zone, consisting of Dolomite, Marble, and Oölite, with clayey interlayers, marked by *Cidarites glandarius*.

2. The Sandstone stage, with *Trigonia Syriaca* and *Astarte Libanotica*. With this division the eruptive Melaphyrs are closely associated; and to it also belong the coal-beds which occur in the spring-district of the Nahr el Beirût.

3. The Gasteropod zone of Abeih: † Limestone, Marl, Dolomite, with Nerineæ, Cerithia, and Turritellæ.

4. The Cardium bed: brown Limestone strata with casts of Cardia.

5. The zone of *Ammonites Syriacus*, two hundred meters thick, consisting of gray Limestones, containing Pteroceræ, Hippurites, Orbitulinæ, Ostreæ, etc.

* Verhandlungen des Naturhistorichen Vereines der Preussischen Rheinlande und Westfalens, XXXVIII. pp. 66–114, Bonn, 1881.

† This summary of the nine zones is substantially that presented by vom Rath (op. cit., p. 103). By comparison with page 13 of this memoir, it will be observed that the thick bed of Sandstone (forty meters) there noticed as lying at the base of this zone is not here mentioned. Is the omission an error, or due to the fact that the Sandstone is not fossil-bearing, and so not an essential part of the zone?

6. The Radiolite zone: Cretaceous Marl, crystalline Limestone, Dolomite, fissile Limestone.

7. The Slate of Hakil: Hard fissile Slate, with Fishes, Crabs, Sepiæ, and Echinoderms.

8. Marl, with the Fishes of Sâhil Alma.

9. Chalky Marl, corresponding to the English White Chalk.

Of these members, 1 and 2 belong to the Cenomanian, 3–8 to the Turonian, and 9 to the Senonian of d'Orbigny. Three of them, not to be referred to again, are represented in the Bird collection by other than molluscan species, viz.: the 1st, by the singular spines of *Cidarites glandarius* Lang (*Cidaris glandifera* Goldfuss), the *Lapides Judaïci*, or "Jews' Acorns," "Stone Olives," etc., which, with the Lebanon fossil fishes, were objects of curiosity and wonder to early Oriental travellers from the times of the Crusades; the 7th, by small specimens of two genera of Echinoids, *Salenia* and *Cyphosoma;* the 8th, by Fossil Fishes from the Marl of Sâhil Alma.

Of the Tertiary formation, Fraas agrees with Lartet in recognizing in Syria south of Tarâbulûs (Tripoli) the presence of only the Eocene; but he declares it to be impossible to draw the limit between the Eocene and the Cretaceous. He states that Nummulites pass down into the Cretaceous, and asserts, contrary to the doctrine so long accepted, that nowhere in the region does the finding of a Nummulite make it certain that the bed in which it lies is of Tertiary age; while Lartet apparently adheres to the older view. The Bird collection contains specimens of what Lartet regards as *Nummulites Lyelli* Archiac.

Lartet declares the presence of the Miocene, so fossiliferous near Cairo and on the isthmus of Suez, as well as of the Pliocene, not proved by the evidence of fossils to exist in the parts traversed by himself. But he is inclined to assign to the Tertiary, without specifying the age more precisely, certain detrital deposits found in Palestine and Idumæa. Fraas, however, on an excursion to Mount Terbol (or Turbul), a spur from the northern part of the Lebanon range, a few hours' journey from Tarâbulûs, discovered a "surprising mass" of Tertiary detritus, resting upon a floor of yellow calcareous rock. In this limestone he distinguished bulky Corals, *Ostrea longirostris*, and many other fossils which warranted him in pronouncing the beds to be of Miocene age.

It may not be out of place to add, that during a brief interview with Professor Zittel, of Munich, after the determinations and descriptions noted in the following paper were mainly completed, his attention was called to the outspread specimens of the several collections. He did not hesitate to express his opinion that, as a whole, the Cretaceous portion must be regarded as of later than Cenomanian age. Though given after a hasty and general survey, this opinion is significant as being that of an eminent palæontologist, and confirmatory of the view of an able and experienced geologist. It has weight, not only on account of Professor Zittel's reputation for great learning in the wide field of Palæontology, but because the Cretaceous system has been an object of his special study.

Cambridge, February, 1884.

SYRIAN MOLLUSCAN FOSSILS.

CEPHALOPODA.

The few Ammonites included in the following list, being species which were long since described, are designated by the names applied to them in the works quoted in this paper. To substitute for the older and more familiar generic names those which have been introduced by the most recent investigators, would not subserve our present purpose.

JURASSIC AMMONITES.

Of the three species here presented, representatives of two are from Dr. Merrill, and were obtained by him at Mejdel esh Shems, a Druse village situated, as already stated, upon the southerly slope of Mt. Hermon, at an elevation of 1,340 meters, over which passes the frequented road from Baniâs to Damascus. The village stands upon a narrow strip of Jurassic rock, the only exposure of that formation up to a recent date discovered in Syria. The Ammonites found in this vicinity are all recognized European Jurassic forms, and the three here presented, with some others, occur in a bed of what is known to German palæontologists as the *Ornati Clay*, part of their uppermost *Brown Jura*, and nearly equivalent to the *Oxford Clay* of the English *Middle Oölite*.

The fact that these species have been hitherto known as occurring in Syria only at this single locality, leads to the inference that the specimens received from Mrs. Bird were derived from it, though they came as part of a collection purporting to have been made in Abeih and its vicinity,

where only Cretaceous strata have as yet been detected. The inference is justified by the identity of mineral character observed in the specimens from both the Merrill and Bird collections. All are pyritiferous, and bear externally a bright metallic gloss, mentioned by Fraas as marking the Ammonites of this bed of Ornati Clay, which are, in his own words, *alle glänzend verkiest*.

It is known that the pupils of the mission stations established at Mejdel esh Shems and Abeih are encouraged by their teachers to gather up the fossils which abound in both districts, and that by them has been brought together a large part of the fine collection now exhibited in the college at Beirût. It was probably from the station at Mejdel esh Shems that these Jurassic Ammonites were procured.

The specimens are all in excellent condition, generally retaining the delicate test, which is, however, in some instances removed or worn thin, so as to show the complicated lobes of the septa.

In accordance with the foregoing statement, all may be considered as coming from Mejdel esh Shems and the Ornati Clay.

Ammonites convolutus Schlotheim.

? *Nautilus polygyratus* Reinecke, 1818, Nautili et Argonautæ, p. 73, Pl. v, figs. 45, 46.
Ammonites convolutus Schlotheim, 1820, Petrefactenkunde, p. 69.
Ammonites convolutus ornati Quenstedt, 1849, Cephalopoden, p. 168, Pl. xiii, fig. 1.

Six specimens. The largest, having a diameter of 24 mm., width of last whorl, 9 mm., thickness of same, 9 mm., answers well to Quenstedt's figure, and precisely to that of Loriol and Pellat (Monogr. des Étag. sup. de la Format. Jurass. de Boulogne-sur-Mer, p. 35, Pl. i, fig. 18), which represents an example from Baden, at first "faussement attribuée à l'*Am. Quehenensis*" Loriol, 1873, but, it is added, "qui appartient au group de l'*Am. polygyratus*." The ribs of this specimen curve forwards more than do those of the species *communis* Sow. and *plicatilis* Sow., while they are finer than in the former and coarser than in the latter. Many of the ribs are trifurcate as they pass over the back; others are bifurcate. Coll. Bird.

There are, besides, five much smaller specimens, varying in diameter from $12\frac{1}{2}$ mm. down to 8 mm., and which I take to be the young of this species. These are from Dr. Merrill, who obtained them at Mejdel esh Shems.

Ammonites hecticus (Reinecke) Hartmann.

Nautilus hecticus Reinecke, 1818, Nautili et Argonautæ, p. 70, Pl. iv, figs. 37, 38.
Ammonites hecticus Hartmann, 1830, Versteinerungen Würtembergs, p. 21.
" " Bronn, 1835–37, Lethæa Geog., p. 428, Pl. xxii, fig. 9 *a*, *b*–10 *a*, *b*.
" " d'Orbigny, 1842, Paléont. Franç., Terr. Jurass., I, p. 432, Pl. cli, figs. 1–5.
" " Quenstedt, 1849, Cephalopoden, p. 117, Pl. viii, figs. 1 *a*, *b*.
" " Quenstedt, 1858, Der Jura, p. 544, Pl. lxxi, figs. 21, 22.

Six specimens. Dimensions of four: —

1. Diameter, 30 mm.; width of last whorl, 13 mm.; thickness of same, 7 mm.
2. " 27 mm.; " " " 13 mm.; " " " 7½ mm.
3. " 26 mm.; " " " 13 mm.; " " " 7 mm.
4. " 26 mm.; " " " 12 mm.; " " " 7 mm.

Examples 1 and 4 agree well with figures of Bronn and Quenstedt, and with fig. 4 of d'Orbigny; while 2 and 3 seem to represent var. *lunula*, as figured by Bronn, op. cit., Pl. viii, figs. 2 *a*, *b*. Coll. Bird.

Two specimens, smaller than 1–4 and obscurely marked, are probably of this species, of which two varieties are recognized. These were obtained at Mejdel esh Shems, and are from the Merrill collection.

Ammonites fuscus Quenstedt.

Ammonites fuscus Quenstedt, 1858, Der Jura, p. 475, Pl. lxiv, figs. 1–3.

Single specimen. Diameter, 26 mm.; width of last whorl, 14 mm.; thickness of same, 11½ mm.

In size, proportions, and markings it agrees perfectly with Quenstedt's figure 1. Umbilicus very small, each successive volution almost wholly covering that which precedes. Coll. Bird.

CRETACEOUS AMMONITES.

Ammonites Syriacus Von Buch.

Ammonites Syriacus, L. von Buch, 1849, Ueber Ceratiten, p. 20, Pl. vi, figs. 1–3.
" " Conrad, 1852, Official Report, p. 221, Pl. xiv, fig. 74.

Three specimens. Dimensions of largest (uncommonly fine, and retaining the thin test almost entire): diameter, 52 mm.; thickness, tubercles included, 23 mm.; width of outer whorl at aperture, 25 mm.

Localities. — On the authority of Dr. Merrill, two specimens are from the "Gilead Mountains," east of the Jordan, and from his collection. The third, of which the dimensions are given above, is from Abeih or its vicinity, and from the Bird Collection.

Stratigraphical Position. — Fraas regards the marl, of which this species is the characteristic fossil, as marking the close of the Brown Chalk of German systematists, and as introducing the superimposed Gray Chalk. This marl and beds of some 170 meters in thickness which lie next above, he terms the *Zone of the Ammonites Syriacus*, in his view the third member (ascending) of the Turonian subdivision of the Cretaceous, as developed in Syria. According to the same authority, three zones more follow above before the close of the Turonian and the commencement of the Senonian marl, corresponding to the White Chalk. We may then consider this species as belonging to the middle portion of the Turonian of d'Orbigny, though that author himself (Prodrome, II, Étage vingtième, 11) referred it to his Cenomanian (Upper Greensand), which next precedes his Turonian.

Ammonites Vibrayeanus D'Orbigny.

Ammonites Vibrayeanus D'Orbigny, 1840, Paléont. Franç., Terr. Crét., I, p. 322, Pl. xcvi, figs. 1–3.

Eight specimens, interior casts. In the compressed and flattened form, thin, but truncate back, sagittate aperture, and general proportions, they correspond so closely to d'Orbigny's description and figures of the species above named, that I cannot hesitate to refer them to it. The best preserved of the eight fully accords with d'Orbigny's description in having straight ribs radiating from the umbilicus to the periphery. Yet it is to be noted that the septal lobes agree better with those of *A. Syriacus* than with the lobes of *A. Vibrayeanus*, as figured by d'Orbigny.

It must be of similar, but probably more imperfect specimens, that Fraas remarks (Aus dem Orient, II, p. 78): "The choice becomes difficult whether we ought to reckon them with *Syriacus* or with *Vibrayeanus*."

Diameter of largest, 77 mm. The specimen mentioned above as the best preserved has the dimensions: greatest diameter, 68 mm.; greatest thickness, 19 mm.; width of outer volution at the aperture, 37 mm. Coll. Thomson.

Locality and Position. — Probably the Beirût district; from same horizon as the last species.

Ammonites Libanensis? Conrad.

Ammonites Libanensis Conrad, 1852, Official Report, p. 234, App., Pl. vi, fig. 46.

Fragment of the cast of an outer whorl, apparently from the upper posterior portion of an individual of the species above named. Width of whorl, 60 mm.; thickness, 63 mm. Measured along the dorsal surface, the fragment has a length of 70 mm. It bears nine transverse ribs, little prominent and about as wide as the interspaces.

The specimen is too small a part of the whole fossil, and too imperfectly preserved, to admit of positive identification. Coll. Merrill.

Locality and Position. — Beirût district; probably from the same horizon as the last two species.

GASTEROPODA.

Of the species enumerated under this title, those designated as being from the Bird collection are from Abeih, or its vicinity, and agree in their rock material with the beds of Fraas's *Gasteropod zone of Abeih*, the lowest of six members which, according to his view, make up the Turonian stage of the Cretaceous of that region. At Châu Shamûr, near Abeih, a natural profile shows the zone to have seven subdivisions, of which there need be mentioned here only the lowest, a thick bed of red and yellow ferruginous sandstone, and two thinner and higher beds of yellow marl. The latter rock is spoken of as especially exposed at Abeih, and as yielding, through weathering, the well-preserved Gasteropods for which that locality is famous above all others of the region. Fraas's language implies, but does not definitely assert, that the marl only is productive of recognizable species. Our specimens show this marl to be for the most part soft and earthy, with intermingled bits of broken shells; but the rock material associated with our finest univalves from Abeih is arenaceous, composed indeed of calcareous — not siliceous — grains, and, like the earthy marl, ferruginous and mingled with the *débris* of shells. Were the sandstone above mentioned known by us to be friable and to furnish well-preserved shells, we should suppose the species in question to be from that portion of the zone. But in the absence of proof that the sandstone is thus prolific, we must regard them as coming probably from an arenaceous portion of the marl, and shall so refer to them.

The Gasteropods of the Thomson and Congregational House collections agree in rock material with those of the Bird collection, and were sent home from Beirût by American missionaries, one of whose principal stations is Abeih. It is therefore altogether probable that they were procured from that locality, since it yields the most abundant and attainable supply. But to guard against possible error, we will, in our discussion of the several species, speak of them as probably from the Beirût district, — already defined. The specimens of the Merrill collections, with a few exceptions, we know to be from that district.

Lunatia Gileadensis, sp. nov.

Plate I, fig. 1.

Testa ponderosa, globoso-turbinata: spira elata, acutiuscula: anfractus circiter quinque rotundati, subito crescentes, prope marginem posteriorem subdepressi; sutura perspicua: apertura lunata; labium postice calloso-reflexum; umbilicus apertus angustior, pervius, sine funiculo.

Shell thick and heavy, globosely turbinated: spire elevated, rather sharp: whorls about five, rounded, slightly depressed at the posterior margin; suture well marked; aperture semilunar; columellar lip callously reflexed behind; umbilicus open, rather narrow, pervious, not funiculate.

Single specimen, with portions of the body-whorl broken away. Length, 87 mm., original length about 95 mm.; width, 76 mm., originally about 85 mm.

This species most resembles the recent *Lunatia heros* Say, differing from it chiefly in having a more elevated spire, and the body-whorl rather more produced anteriorly. The umbilicus is not narrower than is seen in many specimens of *heros*.

The specimen is completely silicified, and is incrusted without and within by a layer of siliceous concretions. The concretionary layer (perhaps deposited while the fossil lay in a cavity) is of moderate and uniform thickness, as is evident from the fact that the shell retains the just proportions of all its parts. The thickness of the outer lip and parts adjacent ranges from 7 mm. to 9 mm., as measured upon the fractured edge and along a section exposed by the removal of a triangular portion broken out in procuring the specimen, but cemented back in place before the figure was drawn. The shell must therefore have been originally of unusual thickness, far exceeding in this respect the most ponderous species of recent *Neveritæ*,

which, in fact, have the corresponding parts of the body-whorl always comparatively thin. Coll. Merrill.

Locality and Position. — Mountains of Gilead, east of the Jordan. Probably Cretaceous.

Natica Syriaca Conrad

Natica Syriaca Conrad, 1852, Official Report, p. 220, Pl. xii, fig. 70.

A single, small interior cast. Length, 43 mm.; width, 37 mm. Coll. Thomson.

Locality and Position. — Probably the Beirût district; from the yellow Turonian marl.

Amauropsis subcanaliculata, sp. nov.

Plate I, fig. 5.

Testa ovato-elongata; spira elata, fastigata, apice acuminato: anfractus septem, a lateribus applanati, postice angulati et gradato-subcanaliculati; ultimus dimidiam longitudinem testæ paulo superans, ad angulum latissimus, prorsum coarctatus denique productus: sutura pæne linearis, vix impressa, margine exili antice circumdata: apertura longitudinalis, angusta, antice paulum attenuata; columella imperforata, callo obtecta.

Shell ovate-elongate; spire elevated, fastigiate, apex acuminate: whorls seven, flattened on the sides, posteriorly rather roundly angulate and gradate-subcanaliculate; body-whorl a little exceeding half the total length of the shell, broadest at the angle, narrowing forwards and produced in front: suture almost linear and scarcely impressed, and bordered by a thin and slightly elevated rim rising from each successive whorl: aperture longitudinal, narrow, moderately attenuated in front; columella imperforate, apparently thinly overspread with callus.

Described from a single specimen retaining the test nearly entire. Length, 64 mm., originally about 66 mm.; width, 33 mm., original width about 35 mm.; length of body-whorl to suture, 34 mm.; length of spire, from suture of body-whorl, when entire, about 32 mm.

Comparison of the specimens named under the above and the next following title with a series of *Natica bulbiformis* Sow. (*Buccinites labyrinthicus* Schlotheim) from Sowerby's original Alpine Gosau locality, convinces me that the three species must be associated in the same ultimate subdivision, generic or subgeneric, whether that group be termed *Euspira* or

Amauropsis. As the application of the former name seems not yet to be definitely settled, I have for the present followed Zittel in assigning *bulbiformis* (and with it the other two species) to *Amauropsis*, though it may be questioned whether the name is justly applicable to any one of the three.

Besides the resemblance of the three species in general form, and in characters of mouth and spire, their striking similarity in the region of the suture is to be observed. In the several species each volution terminates behind in a more or less truncately flattened area, bounded within, next to the suture, by a thin and slightly elevated rim, and without, in two of the species, by a distinct, rounded, backward-projecting varix, which, with the internal rim, accompanies the area to the top of the spire. The space between the rim and the varix constitutes a canal, deep and flat-floored in *bulbiformis;* less deep and with bottom sloping outward, but sufficiently marked, in the present species; while in the following one it becomes a slightly concave shelf, bounded inside by the small but persistent sutural rim, and externally by the varix, present indeed but reduced to a minimum. In all three species is found the same lightly impressed and almost linear suture, the canaliculation being wholly outside the suture proper and distinct from it. Coll. Bird.

Locality and Position. — Abeih; from the arenaceous Turonian marl.

Amauropsis gradata, sp. nov.

Plate I, fig. 3.

Testa late-ovata; spira elevata, pyramidata, apice acuto: anfractus sex, a latere applanati, postice prope suturam acute angulati et late tabulati, spira speciem scalarum gerente; anfractus ultimus spira longior, latior quam longior, ad angulum latissimus, prorsum subito contractus: sutura linearis margine exili infra circumdata: apertura sublunata, antice producta et incurvata, postice biangulata; labrum simplex; columella excavata, rimam umbilicalem exhibens.

Shell broadly ovate; spire elevated, pyramidal, having the apex acute: whorls six, flattened on the sides, behind near the suture sharply angled and widely tabulate, the spire showing the form of a winding staircase; last whorl longer than the spire, wider than long, broadest at the angle and thence rapidly diminishing forward: suture linear, bordered by a narrow margin slightly raised on each whorl: aperture sublunate, in front produced

and curved, posteriorly biangulate; outer lip simple; columella excavated, showing a chink-like umbilical opening.

This species is described from a single specimen of the following dimensions: length (nearly entire), 39 mm.; greatest width, 28 mm.; length of body-whorl slightly shortened, 21 mm.; length of spire, 18 mm. Coll. Bird.

Locality and Position. — Abeih; from the arenaceous portion of the Turonian Marl.

Amauropsis Abeihensis, sp. nov.

Plate I, figs. 2 a, b.

Testa subglobosa; spira brevis, acuminata: anfractus sex, subconvexi, sutura angusta excavata sejuncti; ultimus valde inflatus, ad medium latissimus, latior quam longior; superficies striis incrementi crasse notata: apertura obovata, dilatata, postice angustata, antice lata ac rotundata; labium tenue; columella rimata et ad terminationem furcata.

Shell subglobose; spire short, acuminate: whorls six, subconvex, separated by a narrow but excavated suture; the last whorl greatly inflated, widest at the middle, broader than long; surface coarsely marked with striæ of growth: aperture obovate, expanded, narrowed behind, in front wide and rounded; inner lip thin; columella fissured, and at the end forked.

Single specimen. Length, 24 mm.; length of last whorl, 18 mm.; width, 20 mm.

Like *Euspira pagoda* Forbes, 1846 (Trans. Geol. Soc. Lond., VII, p. 136, Pl. xii, fig. 14), this specimen has the posterior edge of its volutions rounded and descending into a narrow canaliculate suture. The spire is less elevated than in *pagoda*, and the last whorl is relatively much larger. The shell most resembles *E. spissata* Stoliczka (Cretac. Gast. of So. India, p. 303, Pl. xxii, figs. 3, 4), the body-whorl of which, however, has the surface punctate, is more gradate, being flattened behind and upon the sides near the suture, and is less ventricose. *Abeihensis* and *spissata* agree in proportions of spire and form of aperture, and both have the columella anteriorly flattened and distinctly grooved; but in *spissata* it is not fissured, while in the present species the groove ends behind in a chink-like umbilicus. *E. lirata* Sow. (also Cretaceous) differs from both the last mentioned species in having a deep and conspicuous umbilicus, as well as in other respects.

More nearly than *A. subcanaliculata* and *gradata*, the present species corresponds to the recent typical *Amauropsis* in the character of its suture and

spire, and seems therefore more appropriately to bear that generic name. Coll. Bird.

Locality and Position. — Abeih; from the arenaceous portion of the Turonian marl.

TYLOSTOMA Sharpe.

This genus, instituted by Sharpe in 1849 (Quart. Journ. Geol. Soc. Lond., V, p, 376), is identical with *Varigera*, designated by d'Orbigny in 1850 (Prodr. de Paléont., II, p. 103). It is characteristic of the Cretaceous system in Portugal, from which Sharpe described four species. Pictet and Campiche have since named eight from the Cretaceous beds of Sainte-Croix, Switzerland, and still later (1867) Stoliczka has recorded three species from the Cretaceous of Southern India; but the genus has not been recognized hitherto among the fossils of Syria. It is assigned to the family *Naticidæ*.

Tylostoma Birdanum, sp. nov.

Plate I, fig. 4.

Testa ovato-elongata, subturrita; spira elata, conica, acuminata: anfractus septem convexi, vix gradati, striis incrementi crassioribus insigniti, varicibus externis prope continuis in ordines duos fere oppositos redactis muniti; ultimus longitudinem spiræ paulo superans et latior quam longior; sutura profunda: apertura ovato-lunata, antice rotundata, postice angulo acuto terminans; columella rimulata.

Shell ovate-elongate, subturreted; spire elevated, conical, acuminate: whorls seven, convex, very slightly tabulated at the posterior margin, marked with rather heavy lines of growth, and bearing two rows of nearly continuous varices, distant from each other about half a volution; last whorl but little longer than the spire and wider than long; suture deep: aperture ovate-lunate, rounded in front and terminating behind in an acute angle; columella slightly fissured.

The species is described from a single specimen of the following dimensions: length in present condition, 38 mm.; original length, approximate, 40 mm.; length of body-whorl restored, 21 mm.; its width, 27 mm.; length of spire measured from body-whorl, 19 mm.

The specimen here described is one of very few of its genus which have been found retaining the test. The only parts wanting are a small trian-

gular portion of the anterior extremity, a little of the outer lip, and a small oval patch on the dorsal side of the penultimate whorl, where is found a perforation into the interior of the shell. The specimen is remarkable for exhibiting well-marked external varices on the front of the three largest whorls, distinguishable also upon the back, but less perfectly preserved. They are remains of somewhat dilated margins of successive outer lips, directly within which occur the internal varices characteristic of the genus, but not visible in our example. In several species no traces are found of external varices, which therefore have been regarded as not of generic value, though in some instances they may have been worn away, as often happens to shells of *Scarabæus*.

I have named this species after Rev. William Bird, missionary of the American Board, now and for many years stationed at Abeih. In the spire it closely resembles *T. Rochatianum* Pictet and Campiche, from "l'Étage Aptien inférieur," (Descr. des Foss. du Terr. Crét. de Ste.-Croix, II, p. 356, Pl. lxxiii, figs. 12, 13,) which, however, is not known to have external varices, and is proportionally longer and narrower. Coll. Bird.

Locality and Position. — Abeih; from the arenaceous portion of the Turonian marl.

Tylostoma Syriacum Conrad sp.

Plate I, figs. 6 a, b, and Plate II, fig. 10.

Chenopus Syriacus Conrad, 1852, Official Report, p. 220, Pl. xii, fig. 71.

? *Natica elatior** Coquand, 1862, Géol. et Paléont. de Constantine, p. 179, Pl. iii, fig. 5.

? *Tylostoma fallax* Pictet and Campiche, Sept., 1862, Foss. du Terr. Crét. de Ste.-Croix, II, p. 331, Pl. lxxiii, figs. 3, 4.

Five interior casts, of which three are very imperfect. Of the best two the following are the dimensions. The larger, Coll. Merrill (Pl. i, figs. 6 *a*, *b*): length, shortened at tip of spire, 83 mm.; original length, approximate, 92 mm.; width, compressed, 45 mm. The better, Coll. Thomson (Pl. ii, fig. 10): length, spire shortened a little, 70 mm.; original length, about 75 mm.; width, natural, 44 mm.

That the fossils to which I have assigned the name *Tylostoma Syriacum* may be identified with absolute certainty, comparison should be made with Conrad's type; but his Syrian types are not at present to be found. There

* In Coquand's *Études supplémentaires sur la Paléontologie Algérienne*, 1880, received since the above was written, the author has changed the name of his *Natica elatior* to *Tylostoma elatius*.

is reason to doubt the accuracy of his delineation of the specimen figured, which he styles "a cast somewhat distorted."

The examples on which my determination is chiefly based are the two casts measured above. Of each, five volutions remain, — two more seeming required to complete the larger, and one to complete the smaller.

The fossils included under the names placed above, as probably synonyms, agree in number of whorls, proportions, spiral angle, and (with trifling allowance for distortion) in form of aperture, and in respect to size quite as closely as would several adult individuals of one and the same species. From figures alone it seems impossible to establish tenable distinctions between them. They all differ widely from *Natica* in the following points. The aperture is much less oblique, and posteriorly terminates in an acute angle. The columellar lip is very nearly straight, and the body-whorl is proportionally too small and the spire too elevated for *Natica*.

The characters last enumerated indicate that these so-called species should be referred to the genus *Tylostoma*. Neither the figures nor our casts show, indeed, any impressions left by internal varices, a point upon which Pictet and Campiche remark, under their diagnosis of *Tylostoma* (op. cit., II, p. 350): "Les varices ou impressions du labre ne sont certes pas un caractère important; mais ce qui l'est davantage, c'est la constance de la forme de la bouche, rappelant celle des Natices, mais en étant bien plus étroite et plus modifiée par l'avant-dernier tour." Again, of *T. fallax* the same authors write (op. cit., II, p. 351): "On ne voit sur le moule de l'adulte que des traces bien douteuses ou effacées des bouches successives; mais si, comme nous le pensons, on doit rapporter à la même espèce des moules plus petits qui ont exactement les mêmes proportions, nous pouvons ajouter que dans les jeunes les impressions sont visibles et profondes deux fois par tour."

Conrad noted the resemblance of his *Chenopus Syriacus* to *Natica prælonga* Desh. (Leymerie, 1840, Mém. Soc. Géol. de France, (1,) IV, p. 342; Leymerie, 1842, Ibid., (1,) V, p. 13, Pl. xvi, fig. 8; d'Orb., 1842, Paléont. Franç., Terr. Crét., II, p. 152, Pl. clxxii, fig. 1; d'Orb., 1842, Voy. Amer. Mérid., III, Pt. 2, Paléont., p. 78, Pl. xviii, fig. 1); and it may be insisted by some that his figure corresponds to the figures of that species rather than to those of *elatior* and *fallax*. But if the outlines of the aperture in Conrad's figure be restored, and if his representation of the columellar lip is accurate, his species, as already remarked, must be referred to *Tylostoma*. The resemblance of the three so-called species named above to *Natica prælonga* is very striking.

Say Pictet and Campiche (op. cit., II, p. 352): "Le *T. fallax* est facile à confondre avec le *Natica prælonga* d'Orb., dont il a tout à fait les dimensions, l'angle spiral, etc. Il a été souvent placé sous ce nom dans les collections et probablement cité dans les catalogues. Il est du reste bien distinct, et si les moules ne sont pas encroûtés, on reconnaît facilement le Tylostoma à son ouverture étroite, bien moins oblique, aigu en arrière, et à son bord columellaire presque droit."

Though *N. prælonga* is still recognized as a distinct species by the Swiss palæontologists just quoted, and by Coquand, who claims to have found in Algeria both that and his species *eladior*, it would not be surprising if the study of fuller suites of all the above named (hitherto known only from casts), together with the careful observation of their variations and distortions, should lead to their reduction to a single species.

Coll. Merrill, Thomson, and Congregational House.

Locality and Position. — Beirût district; from a yellow ferruginous marl, probably identical with that of Abeih.

? Tylostoma depressum Pictet and Campiche.

Plate I, fig. 7.

Tylostoma depressum Pictet and Campiche, 1862, Foss. du Terr. Crét. de Ste.-Croix, II, p. 355, Pl. lxxiii, figs. 10, 11.

Single internal cast, incomplete at apex, four whorls remaining. Length, 63 mm., originally about 70 mm.; width, 53 mm.

This seems to be an adult specimen of the Swiss species named above, of which Pictet and Campiche figure two casts of immature individuals, bearing impressions of the internal varices. They represent *T. depressum* as being distinguished "par ses proportions et par la forme de son dernier tour, qui est court, déprimé à sa partie antérieure, ce qui rend la bouche courte, obtuse et oblique." (loc. cit.) This description applies without qualification to the Lebanon fossil.

Coll. Congregational House.

Locality and Position. — Probably the Beirût district; from a yellow marl, apparently identical with that of Abeih.

Tylostoma induratum Conrad sp.

Plate I, figs. 8 a, b.

Chenopus induratus Conrad, 1852, Official Report, p. 220, Pl. xi, fig. 69.

Two internal casts. Dimensions of largest: length, shortened at each extremity, 53 mm.; original length, approximate, 60 mm.; width, a little compressed, 37 mm.

In size, proportions, shape of aperture, and columellar lip, these casts correspond to Conrad's figure and description; but their characters indicate that they belong to a species of *Tylostoma* closely related to (possibly identical with) *T. Torrubiæ* Sharpe (Quart. Jour. Geol. Sci., London, V, p. 378, Pl. ix, figs. 1, 2). Of such casts the specific descriptions must be necessarily imperfect. Lartet observes (Expl. Géol. de la Mer Morte, p. 120), "Le moule que M. Conrad figure sous ce nom [*Chenopus induratus*] pourrait bien se rapporter à un autre genre." Coll. Merrill.

Locality and Position. — Beirût district; from a yellow marl, apparently identical with that of Abeih.

Turritella elæonis, sp. nov.

Plate II, figs. 1 a, b.

Testa parva, tenuissima, pyramidali-turrita: anfractus octoni seu noveni, ad suturam valde constricti, lineis incrementi insinuatis striati, medio unicarinati, a carina utrinque ad suturam plano-declives: carina angusta, in anfractibus summis elevata, acutiuscula: basis truncata, ad peripheriam carinata et acute angulata, inferne applanata: superficies anfractuum infra carinam filo uno tenui, supra duobus tenuissimis parallelis cincta: apertura transversim et anguste ovata.

Shell small, exceedingly thin, pyramidally turreted: whorls eight or nine, strongly contracted at the suture, striated with sinuous lines of growth, in the middle one-keeled, from the keel sloping in both directions to the suture: keel narrow, on the upper whorls elevated and rather sharp: base truncate, flattened below, keeled and acutely angled at the periphery: surface of the whorls below the median keel encircled with a single delicate thread, and above the keel with two still more slender and parallel ones: aperture transversely and narrowly ovate.

Two specimens. One retains the test and six entire whorls, with part of

a seventh above. Length, 20 mm.; when complete, about 22 mm.; width, increased by pressure, 8 mm. The other is an internal cast, with five entire whorls and parts of others.

The most remarkable character of this species is to be found in the flatly truncate base, making nearly a right angle with the axis of the shell (as in a few recent species), and bearing at its periphery a sharp keel, which on each preceding whorl is covered by the growth of the following volution. The aperture is incomplete, transverse, and narrowly oval (perhaps through pressure), and the columellar lip is turned very abruptly outward from the flat base. Some whorls of the cast show a single delicate raised line halfway between the median keel and the suture below, while midway from the keel to the suture above run two parallel fainter threads. These threads can hardly be distinguished, except with a lens, and on the specimen retaining the test are obscured by the lines of growth, which by their deep curve prove that the lip was strongly insinuate at the middle. The lines of growth are heaviest upon the flat base. Coll. Bird.

Locality and Position. — Mount of Olives. If Fraas is correct in regarding the fossils on the whole line from Jaffa to the Dead Sea as belonging to the Upper Cretaceous (Turonian and Senonian), this species is probably from that horizon.

Turritella sp.?

Plate II, figs. 2 a, b.

Fourteen casts incomplete. Coll. Thomson.

Locality and Position. — Probably Beirût district and from the Turonian Gasteropod zone.

Scalaria sp.?

Plate II, figs. 3 a, b.

Three internal casts, incomplete and somewhat flattened by pressure.

Largest, having four whorls, length, 49 mm.; width, increased by flattening, 25 mm. Fragment having two whorls and part of a third, length, 34 mm.; width, flattened, 24 mm.

Distinct traces of longitudinal ribs upon one of the casts indicate that the specimens belong to *Scalaria* rather than *Turritella*. The well-known *S. Dupiniana* d'Orb., from Campiche's Sainte-Croix collection, in the Museum

of Comparative Zoölogy, also shows upon casts the remains of longitudinal ribs, and considerably resembles these specimens.

As the *Scalaridæ* are only doubtfully represented in the Jurassic formation, these casts go to confirm the view that the beds from which they were taken are not older than the Cretaceous period. Coll. Merrill.

Locality and Position. — Beirût district; from the arenaceous marl, probably Turonian.

Eunema? bicarinata, sp. nov.

Plate II, figs. 5 a, b.

[*Turbo* auct.; *Amberleya* Morris & Lycett, 1850, but inadequately defined, Moll. from Gr. Ool., Pt. I, p. 54; *Eunema* Salter, 1859, Canad. Organ. Remains, Dec. I, pp. 24 and 29, Pl. vi, fig. 4; *Eucyclus* Eudes-Deslongchamps, 1860, Mém. Soc. Linn. de Normandie, V, p. 138.]

Testa turbinato-conica, tenuiscula, haud umbilicata: anfractus quinque vel sex, carinis duabus, superiori juxta suturam, secunda majore supra medium posita, muniti; ultimus intra carinas alte concavus, infra liris tribus cinctus: apertura superne canaliculata, inferne rotunda; labium exsertum a pariete distinctum.

Shell turbinate-conic, rather thin, without umbilicus: whorls five or six, strengthened by two keels, the upper placed near the suture, the second and larger below the other, but above the middle of each volution; the last whorl deeply concave between the keels and below them encircled by three ridges: aperture channelled behind, round in front; inner lip considerably projecting and separate from the body-wall.

Single specimen, almost entire. Length, 33 mm.; width, 23 mm.

The test of the specimen figured is too badly weathered to show, had they once existed, the "strongly sinuate, prominent, and threadlike lines of growth" (Salter, op. cit., p. 24) which mark the typical species. In other respects the shell agrees with the diagnosis of the genus as given by Salter and Morris and Lycett. One character noted by the last-named authors is very conspicuous in this example, viz.: "The whorls are received into the concavity of those which succeed, the latter at their junctions being slightly overwrapped by the former." (loc. cit.) In this instance the ridge next below the greater keel seems to overlap and nearly hide the suture just beneath. Our shell strongly resembles Salter's typical species, *strigillata*, in its sharp and prominent revolving ridges, posterior canal, and inner lip "not reflected or pressed closely against the columellar base." (Salter, op. cit., p. 29.) Fig. 5 *a* shows within the aperture a deposit which, were

it not for the distinct posterior canal, might be considered a layer of the shell inside the outer, such as occurs most conspicuously in *Monodonta labio* Linn., and some species of *Osilinus*. On careful examination, this seems to be no part of the original shell.

The genus *Eunema*, to which I am inclined to refer this species, — though not without hesitation, — is reported as ranging from the Silurian to the Cretaceous formation. Zittel, in his recent *Handbuch der Palæontologie*, I. Band, 2. Abtheilung, p. 189, 1882, assigns it to the subfamily *Turbininæ*. Salter, Morris and Lycett, and Stoliczka concur in regarding it as belonging to the *Littorinidæ*. In the specimen before us, the mode in which the last whorl receives the preceding one finds no counterpart in any member of the *Turbininæ*, while the general resemblance to *Tectarius*, and especially the likeness in the junction of the volutions and in the spiral ridges (not in the aperture) to the recent Australian *Osilinus constrictus* Macleay, forcibly suggest the relation of the fossil to the *Littorinidæ*. Coll. Bird.

Locality and Position. — Abeih; from the Turonian yellow marl.

Nerinea pauxilla, sp. nov.

Plate II, fig. 4.

Testa parva, acuminato-turrita; spiræ angulus 27°, *suturæ* 93°; *anfractus circiter duodecim, medio profunde excavati et striis volventibus minimis notati; margines elevati et minute crenulati, posterior fortior: apertura subquadrata, canaliculata; columella biplicata, imperforata; labri notæ incognitæ; canalis brevis ut mihi videtur recurvus.*

Shell small, acuminately turreted; angle of spire 27°, of suture 93°; whorls twelve or more, deeply excavated in the middle and marked with very small encircling lines; margins elevated and minutely crenulated, the hinder being larger than the anterior: aperture subquadrate, canaliculate; columella with two folds, imperforate; characters of outer lip unknown; canal short and apparently recurved.

Single specimen, adhering to a mass made up chiefly of broken shells, and strongly ferruginous. Length, 16 mm.; width, 6 mm.

Of the many other species described, none correspond very nearly to this. The Jurassic *N. cæcilia* d'Orb. — much larger — is perhaps most like it in superficial markings. As in some other species of the same genus, the upper margin of each whorl is larger, more prominent, and more crenulated than

the adjacent lower margin of the preceding whorl; while in *Turritella* the lower margin is larger and often rougher than the upper, known as the sutural band, which is usually rather smooth. Weathered, adherent, and with the outer lip broken away, as is the single specimen, its specific description cannot be very full or exact. Coll. Merrill.

Locality and Position. — Mountains of Gilead. To the same fragmental mass with this a specimen of *Rostellaria Rustemi* Fraas is attached, of which Fraas had his examples from the Gasteropod zone at Abeih. Our *Nerinea* must therefore be referred to the same subdivision of the Turonian.

Nerinea gemmifera Coquand.

Nerinea gemmifera Coquand, 1862, Géol. et Paléont. de Constantine, p. 177, Pl. iv, fig. 4.
" " Lartet, 1875, Expl. Géol. de la Mer Morte, p. 119, Pl. viii, fig. 12.

Fifteen specimens, mainly incomplete casts, but in several instances retaining the test. All are completely silicified, and the greater number are tinged reddish or yellowish by oxide of iron. Coll. Thomson.

Coquand instituted the species from examples discovered in Algeria, but afterward met with it in the department of Var, S. E. France. He assigned it to *l'étage provencien*, the upper member of the Middle Cretaceous in the classification which he adopts. Lartet recognized the species at "Jebel el Museikah, near Kurnub, in the southern part of the Judean range." Fraas makes no mention of it.

Locality and Position. — Probably from the vicinity of Abeih. The only fossils in the different collections with which these coincide in character of mineralization are the specimens of *Cerithium gracilens* nobis (see p. 36), from the splintery limestone of the Gasteropod zone of Abeih. The present species may therefore be regarded as in all probability belonging to that stage of the Turonian.

Nerinea (Cryptoplocus) Libanensis, sp. nov.

Plate II, figs. 8 a, b.

[*Cryptoplocus* Pictet and Campiche, 1862 (Foss. du Terr. Crét. de Ste.-Croix, II, p. 257.]

Testa turbinato-conica, longior quam latior, late umbilicata; spiræ angulus 32°: *anfractus circiter septem sive octo, complanati, transverse sulcati, superne ad suturam vittati, ultimus infra angulatus: apertura subquadrata. Ceteræ notæ desunt.*

Shell turbinate-conical, longer than broad, widely umbilicated; angle of spire 32°: whorls about seven or eight, flattened, transversely sulcate, banded above at the suture, the last angled below: aperture subquadrate. The other characteristic marks are unknown by reason of imperfection of the specimen.

Single specimen, a fragment retaining the test. Length, 37 mm.; when entire, about 50 mm.; width, 28 mm.

In respect to size, general proportions, and the sutural band, this shell is very similar to *Cryptoplocus cingulatus* Zittel, 1873 (Gastrop. der Stramb. Schichten, p. 261, Pl. xlii, fig. 20), which, however, from the basal angle upwards is girt with granular ridges. In this specimen, although the test is so much decayed that the original character of its surface is obscured, it can be seen that each whorl was marked with a few distant encircling furrows, but the nature of the intervening ridges is uncertain. The last volution, near the mouth, has been thrust inward enough to compress the aperture somewhat, and to encroach upon the umbilicus, which originally must have been wide and circular. The aperture shows the absence from the labrum and columella of the folds which characterize *Nerinea* proper, but is so closed by stony deposit that it is impossible to determine whether the single concealed fold upon the hinder part of the inner lip, peculiar to *Cryptoplocus*, is present or wanting. Yet the wide and round umbilicus, the quadrate mouth without canal, and their relations to each other, sufficiently distinguish this species from *Turritella*, *Cerithium*, and *Trochus*, the only genera with which it could be confounded.

The resemblance of this fossil to several varieties of *Nerinea pyramidalis* Münster, to *N. depressa* Voltz (*N. umbilicata* Voltz) and *Trochus monoplicus* d'Orb., all of which are now recognized as species of *Cryptoplocus*, tend to support our view of its generic relations.

Pictet and Campiche classified *Cryptoplocus* as a genus distinct from *Nerinea*, while Zittel (Gastrop. der Stramb. Schichten, p. 257, 1873, and Handb. der Palæont., I. Band, 2. Abtheilung, p. 247, 1882) regards it as a subgenus of *Nerinea*. Coll. Merrill.

Locality and Position. — Beirût district; from an arenaceous marl, probably Turonian.

Alaria monodactyla, sp. nov.

Plate II, figs. 6 a, b, c.

[*Alaria* Morris & Lycett, 1850, as restricted by Gabb, 1869, Am. Jour. Conch., V, p. 21, and adopted by Zittel, 1882, Handbuch der Palæontologie, I. Band, 2. Abtheilung, p. 252.]

Testa turrita, fusiformis, alata, caudata: anfractus septeni vel octoni, sutura profunda sejuncti, costis seu varicibus rotundatis exstantibus plerumque continuis armati, filis tenuibus transversis undique ornati; ultimus unicarinatus, penultimi costæ seu varices septem æquales, ultimi incompositæ et partim obsoletæ: apertura trigona; cauda recta plana; ala in digitum rectum brevem evadens; labrum tenue, angustum.

Shell turreted, fusiform, winged and produced into an anterior canal: whorls seven or eight, separated by a very deep suture; armed with rounded projecting longitudinal ribs or varices, generally continuous from whorl to whorl; everywhere ornamented with thin transverse threads which cross the ribs; the last whorl bearing a single keel, the next to the last having seven equal ribs or varices, which on the last become unequal, irregular, and in part obsolete: aperture triangular; canal straight, flat; wing terminating in one short and straight digitation. Inner lip thin and narrow.

Four specimens. Of the best preserved, length, 17 mm., when complete, about 19 mm.; width of body-whorl, without digitation, 8 mm. Of largest, length, 20 mm., originally, about 25 mm.; width of body-whorl, without digitation, 9 mm.

On the last whorl at the distance of half a revolution from the outer lip is a well-marked, Ranella-like varix, which with those of the preceding volutions forms a longitudinal row continuous to the apex; and upon all the whorls, except the last, the ribs or varices are generally arranged in straight unbroken lines, but sometimes irregularly. Two obscure transverse ridges cross the shell where it begins to narrow into the canal. Coll. Bird.

Locality and Position. — Abeih; from the Turonian arenaceous marl.

Rostellaria Rustemi Fraas.

Rostellaria Rustemi Fraas, 1878, Aus dem Orient, II. Theil, p. 67, Pl. vi, fig. 4.

Single specimen adherent to a lump made up of broken and comminuted shells, and side by side with *Nerinea pauxilla* nobis (see p. 25). Length, when entire, about 28 mm.; width, wing wanting, 13 mm.

In neither this nor Fraas's specimen is the wing preserved. Coll. Merrill.

Locality and Position. — Mountains of Gilead. Found also at Abeih and referred by Fraas to his Turonian Gasteropod zone.

Pterocera (Harpagodes) sp.?

Plate II, fig. 7.

A single internal cast, on the back distorted by pressure, and on the right side somewhat broken away. Under surface normal. Length, 109 mm.; width, 75 mm.; height, 65 mm. Of a specimen of *P. Icaunensis*, which retains the test nearly entire, except the digitations and part of the spire, the dimensions, as given, are, length, 118 mm.; width, 93 mm.

Of the larger fossil *Pteroceræ* which have been figured and described, this cast has little resemblance to any but the Cretaceous *P. pelagi* Brongn., and the Jurassic *P. Icaunensis* Cotteau. Careful comparison with the excellent original figures of the former (Ann. des Mines, (1,) VI, p. 554, Pl. vii, fig. 1 *a*, *b*, *c*), and with well-preserved specimens of the same, in the Campiche collection of the Museum of Comparative Zoölogy, from Sainte-Croix, Switzerland, as well as with the numerous figures of *P. Icaunensis*, supplied by the continuation of the Paléontologie Française (Terr. Jurass., III, Pl. xlvi–xlviii, lxxvii, lxxx–lxxxiii), inclines us to believe that the cast belongs to neither species. But the exceptional difficulty which the genus *Pterocera* presents for the determination of fossil species, arising from the rarity of complete examples and their very considerable variations, renders it unsafe to found a new species upon the interesting but distorted cast before us. The aperture seems to have been proportionally narrower than in other large species of the genus. Coll. Congregational House, Boston.

Locality and Position. — Probably the Beirût district; from a yellow marl similar to the beds at Abeih.

Actæonina vafra, sp. nov.

Plate III, figs. 1 a, b.

Testa ovato-cylindracea, obscure rimato-perforata: spira productiuscula, apice acuto: anfractus circiter sex, plano-convexi, ultimus peramplus spiræ longitudinem triplo superans; sutura impressa: superficies striis incrementi nonnunquam fortioribus notata: apertura elongata, postice acuminata, antice latior ac rotundata; labium

prope rectum, reflexum, edentulum, ad marginem anteriorem effusum et incrassatum, postice tenuissimum; labrum tenue.

Shell ovately cylindrical, apparently rimately perforate: spire rather produced and with an acute apex: whorls about six, flatly convex; the body-whorl very large and three times as long as the spire; suture impressed: surface marked with striæ of growth, of which some are quite heavy: aperture elongate, narrowed to a sharp termination behind, in front rather wide and rounded; inner lip nearly straight, spread upon the body wall, without folds, at the front effuse and thickened, while posteriorly it is very thin; labrum thin.

Single specimen, with test. Length, $35\frac{1}{2}$ mm.; width, $18\frac{1}{2}$ mm.

The combination of characters indicates this to be a genuine *Actæonina;* viz. the relative proportions of the spire and body-whorl; the inner lip, before flatly thickened at the edge and neither plicated nor twisted; the aperture evenly rounded in front and sharply angled behind; the last whorl anteriorly somewhat suddenly contracted. Yet the inner lip, conspicuously spread upon the body-whorl through the whole length of the aperture, and the apparent rimate perforation of the columella, distinguish this from any other species of the genus which has been hitherto figured. The seeming, and probably real, perforation is the continuation of a pit formed by an unusual projection of the thickened edge of the inner lip over the concave part of the narrowed front of the body-whorl. It resembles the rimate umbilicus of some species of *Bulimulus*.

In the published figures of *Actæonina olivæformis* Koch and Dunker, the species most like this, good front views are wanting, perhaps from imperfection of the specimens delineated. The back of *olivæformis*, as figured by Morris and Lycett (Moll. Gr. Oöl., Pl. xli, figs. 4, 4 *a*), sufficiently resembles that of our specimen to allow the two to be regarded as specifically identical. But Morris and Lycett's figure of the front (Ibid., Pl. viii, fig. 14), and Koch and Dunker's figures of both back and front (Norddeutschen Oolithgebildes, Pl. v, figs. 3 *a*, *b*), do not agree with the Lebanon fossil. Moreover, no adequate description of *olivæformis* exists, since the original one by Koch and Dunker (Ibid., p. 41, 1837) is brief and meagre, while Morris and Lycett (op. cit., Pt. I, p. 103) have simply copied it without additions. It has therefore seemed best, provisionally at least, to describe the Lebanon shell as a new species. Coll. Bird.

Locality and Position. — Abeih; from the more arenaceous portion of the Turonian yellow marl.

Colostracon, gen. nov.

(κόλος, *decurtatus*; ὄστρακον, *testa*.)

Testa inverso-conica aut decurtato-fusiformis, tenuis; spira valde depressa, plana aut immersa: anfractus quaterni quini vel seni, confertim convoluti, a lateribus planati et plus minusve insinuati, postice truncati acute angulati et ad angulum aliquanto carinati, sutura perspicua divisi; ultimus antice si non in canaliculum at in rostrum tamen porrectus: superficies lineis incrementi notata et per partes spiraliter striata aut leviter sulcata: apertura rectiuscula, coartata, testæ longitudini adæquans, ante medium dilatata, antice angustata; columella arcuata, edentula, prolongata et paulum contorta, labio tenui reflexo modice obtecta, peranguste rimulata; labrum simplex.

Shell inversely conical or decurtate-fusiform, thin; spire greatly depressed, plane or immersed: whorls four to six, compactly convolute, laterally flattened and more or less insinuate, behind truncate, acutely angulate and at the angle considerably keeled, separated by a distinct suture; the body-whorl produced in front into what must be styled at least a beak, if not a proper canal: surface marked with lines of growth and on portions spirally striated or lightly grooved: aperture rather straight, contracted, as long as the entire shell, widened before the medial line, narrowed in front; columella arcuate, without folds, prolonged and somewhat twisted, moderately covered by the thin reflexed labium, very narrowly fissured; labrum simple.

Absence of folds from the columella and the presence of transverse striations upon their exterior exclude these shells from *Cylindrites*, but suggest their classification under *Actæonina*. To the latter genus they would certainly seem to belong, were it not that a short but distinct anterior beak or canal is present in our typical species. And though from imperfection of the specimens it cannot positively be asserted that a similar beak occurs in the second species described by us, nor in that refigured from Fraas, the combination in both of like peculiar and striking characters leads to the inference from analogy that the *beak* can hardly be wanting in perfect examples.

Of the species of *Actæonina* known to us from actual specimens, not one shows any indication of a beaked or channelled aperture. Loriol's figure of his *A. Davidsoni*, étage portlandien (Monogr. des Étages supérieurs de la Formation Jurassique de Boulogne-sur-Mer, p. 44, Pl. vi, figs. 8, 9, 1873),

shows a *semblance* of a beak. So, too, in the original figures of *A. brevis** Morris and Lycett (Moll. Gr. Oöl., Pt. I, p. 101, Pl. viii, figs. 13, 13 *a*, *b*, 1850,—there named *Cylindrites brevis*) appears what might be mistaken for an anterior canal. In the latter case, however, the figures are side views, and give a false impression of the anterior of the shell; for a front view of the specimen afterwards figured in the Supplement of the same work (Pl. xli, fig. 6, 1863), exhibits the "aperture evenly rounded in front," which by all authorities is regarded as a constant character of the genus. The original of this figure (from the Great Oölite of Kirtlington, near Woodstock, Oxfordshire), the only adult specimen known up to the date of Morris and Lycett's Supplement, has been kindly lent to us by the collector, Mr. J. F. Whiteaves, Palæontologist of the Canadian Geological Survey. Of all *Actæoninæ*, this species has the closest general resemblance to the species of the group here considered. Like them it is posteriorly truncate, and has its sides flattened; but its aperture, the lifting of part of the last whorl above the plane of the spire, the rounding of the margins of the truncate convolute whorls, and the smooth surface, as seen in Pl. iii, figs. 2 *a*, *b*, *c* (drawn anew for this paper from the specimen itself), are in strong contrast with the corresponding parts of *Colostracon*.

Without wishing to lay special stress upon the form of the spire, one of the most variable of characters,† we may yet note that forms like *A. concava*,‡ *A. subabbreviata*, *A. Caumontii*, d'Orb., and the various species of *Itieria*,—with which the Abeih species will most naturally be compared,—present posterior extremities (vertices) very unlike those of the latter. In fact, the only known shell which exhibits a vertex as cleanly cut as theirs, is *Raphistoma striatum* (Emmons) Hall, the subtrigonal aperture and deep open umbilicus of which remove it far from *Colostracon*.

In *Cylindrites cylindricus* Morris and Lycett (op. cit., Pt. I, Pl. viii, figs. 19 *a*, *b*, *c*), the cylindrical form and the truncate and acutely margined vertex make the nearest approach to the Abeih species. But the vertex is considerably concave, and of the imperfect anterior part (base) only side

* Is this not identical with *Orthostoma conulus* Buvignier, Statisque Géologique et Paléontologique du Département de la Meuse, p. 32, Pl. xxiv, figs. 16, 17, 1852?

† We are well aware that a continuous series of *Actæoninæ* may be traced from forms which have the spire plane, or even a little immersed, to those which have the same slightly or even strongly elevated.

‡ Formerly regarded as a fossil *Conus*. See the original "Mémoire sur les Cones fossiles des Terrains secondaires du Calvados, par Eudes-Deslongchamps," Mém. de la Société Linnéenne de Normandie, VII, pp. 139–150, 1839–42.

views are given, which leave the character of that part doubtful. No folds are represented upon the columella, and if better preserved specimens should show the base to be rostrate, the sum of characters would obviously require that the species should be assigned to our proposed group.

The comments of Meek* and others, based chiefly on imperfect figures, have been charged with adding to the confusion which already existed in the family *Actæonidæ;* and there seems to be no hope of bringing order out of that confusion, except by the critical study of its representatives from fuller series than are to be found in American collections. It is only from inability to classify our specimens under any of the recognized subdivisions of this unsettled family, that we have ventured to propose in it a new group. We regret the necessity of drawing conclusions from material so scanty.

Colostracon sinuatum, sp. nov.

Plate III, figs. 3 a, b, c.

Testa tenuissima, decurtato-fusiformis, a latere transversim late insinuata: spira maxime depressa, ab apice æqualiter sed minime ad peripheriam declivis; anfractus circiter sex, postice truncati et angulati, ad angulum acute carinati, sutura lineari perspicua sejuncti; ultimus in rostrum breve productus: superficies lineis incrementi fortioribus flexuosis signata, et ante sinum lateralem sulcis exiguis cincta: apertura anomala, ad sinum angustata; labium tenue, super columellam expansum, antice incrassatum; columella paulum contorta, rimulam umbilicarem exhibens.

Shell very thin, decurtate-fusiform, upon the hinder part of the side transversely widely insinuate: spire exceedingly depressed, regularly but very slightly sloping from apex to circumference; whorls about six, truncate and sharply angled behind, acutely keeled at the angle, divided by a distinct linear suture; body-whorl produced in front into a short beak: surface stamped with rather strong flexuous lines of growth, and before the lateral sinus encircled by small shallow grooves: aperture of peculiar shape, narrowed at the sinus; inner lip thin, thickened in front, outspread upon the columella, which is somewhat twisted and shows a slight umbilical chink.

A single specimen, with test nearly complete. Length, 18 mm.; width, at keel, 10 mm.

Figure 3 *c* represents upon the flat posterior side of the aperture succes-

* Remarks on the Family Actæonidæ, with Descriptions of some new Genera and Subgenera. Am. Jour. Science, (2,) XXXV, pp. 84–94, 1863.

sive bent raised lines, which indicate in the progressive growth of the shell the presence of a shallow notch at the edge of the aperture, corresponding on a small scale with the fissure of *Pleurotomaria*. These markings are very like those which have given name to the palæozoic genus *Raphistoma* Hall (Palæontology of New York, I, p. 28, 1847). Coll. Bird.

Locality and Position. — Abeih; from an arenaceous portion of the Turonian yellow marl.

Colostracon curtum, sp. nov.

Plate III, figs. 4 a, b, c, d.

Testa inverso-conica, longior quam latior, spira fere plana, ab anfractus ultimi parte interiori usque ad centrum minime concavus; anfractus quatuor vel quinque centrum versus amplitudine citius decrescentes; ultimi lateribus planis ante angulum parum constrictis: apertura recta, angustiuscula, antice latior: superficies postice striis minutis fluctuosis, antice sulcis exiguis cincta; labrum simplex, tenuissimum; labium anguste ac tenuiter reflexum; columella leviter rimulata.

Shell inversely conical, longer than wide, spire almost plane, very slightly concave from the inner side of the last volution to the centre: whorls four or five, rather rapidly diminishing in thickness towards the centre, having the sides flat and very slightly constricted just before the angle: aperture straight, rather narrow, wider in front: surface encircled behind with minute wavy striæ, before with light grooves; outer lip simple, very thin; inner lip narrowly and thinly spread upon the columella, which is slightly fissured.

Single specimen. Length, 17 mm., originally about 20 mm.; width 12 mm.

In the specimen from which the foregoing description is drawn, the surface is spirally marked behind with minute wavy striæ, and in front by rather wide shallow grooves. Between the two extremities the shell is corroded, but shows traces of lines intermediate in character between those of the anterior and posterior parts, indicating that the whole exterior was originally covered with revolving lines which became anteriorly wider and deeper. It seems probable that in its perfect state the front was produced into an Io-like beak, as in the last species. Coll. Bird.

Locality and Position. — Abeih; from an arenaceous portion of the Turonian yellow marl.

Colostracon Lewisii Fraas sp.

Plate III, figs. 5 a, b.

Globiconcha Lewisii Fraas, 1878, Aus dem Orient, II. Theil, p. 65, Pl. vi, figs. 5 *a*, *b*.

This species clearly belongs to the same genus as the last two, presenting the strong generic characters of the group, yet with differences which separate it specifically from the others. Fraas terms it a *Globiconcha;* but if that genus can be said to have been intelliglibly characterized, which is at least doubtful,* this surely is not a species of the genus.

Having never seen the fossil itself, we copy Fraas's figures and his very brief description of the species, which is as follows: "Eine Muschel von 23 mm. Länge mit zarten Längsstreifen und noch zärteren Querstreifen versehen und einem inneren Canal. Die Windungen, 3–4 an der Zahl, sind vertieft und nabelförmig eingedrückt, wodurch die Muschel ein höchst eigenthümliches Aussehen gewinnt." (loc. cit.)

Locality and Position. — Abeih; from the Turonian Gasteropod zone.

Melo pervetus Conrad sp.

Plate III, fig. 6.

Strombus pervetus Conrad, 1852, Official Report, p. 221, Pl. xiii, fig. 73.

Single specimen, an interior cast, imperfect, but exhibiting very nearly the original outlines. Length, not much abridged, 103 mm.; width, somewhat increased by depression, 63 mm.

Though this is much smaller than the specimen figured by Conrad, precisely the same proportions of spire and body whorl, and the same sutural angle, appearing in both, their specific identity seems altogether probable.

* Stoliczka remarks (Cretaceous Gastropoda of Southern India, p. 410): "When lately at Paris I endeavored to find out from d'Orbigny's collection in the Jardin des Plantes the real signification of the name *Globiconcha*, but I turned away disappointed, not being able to arrive at any reasonable conclusion. Not one of the specimens named by d'Orbigny is a perfect shell, but all imperfect casts, which can be variously commented upon. Some of them have been shown to belong to *Cypræa;* others appeared to me to represent casts of *Tylostoma*, *Natica*, and probably of *Cinulia*. There have been, however, by subsequent authors, various globular shells described under the name of *Globiconcha*, and of these some very much resemble *Bullinula* and *Hydatina*."

Zittel (Handbuch der Palæontologie, I. Band, 2. Abtheilung, p. 296) records the genus under the family *Bullidæ*, in this doubting style: "? *Globiconcha* d'Orb. Auf unbestimmbare Steinkerne von ansehnlicher Grösse aus Kreideablagerungen basirt, welche wahrscheinlich zu verschiedenen Gattungen gehören."

On applying to Conrad's figure a recent *Melo Æthiopica* of corresponding size, such coincidence of outlines appears as convinces the observer that the two are generically equivalent.

Fossil species of *Melo* are rare, but are found in the Cretaceous and Tertiary formations. Stoliczka describes a single species, *M. pyriformis* (Cretaceous Gastropoda of Southern India, p. 83, Pl. vi, fig. 9) from India.

Lartet (Expl. Géol. de la Mer Morte, p. 115), under the heading *Strombus pervetus*, speaks as follows: "Nous avons trouvé au waddy Heïdan un moule de Gastéropode qui se rapproche de cette forme et ressemble ainsi au *Pterocera inornata*." Our specimen and that figured by Conrad, on comparison, will be found *very unlike P. inornata* d'Orb. (Paléont. Franç., Terr. Crét., II, Pl. ccxiv). Coll. Merrill.

Locality and Position. — Beirût district; from a yellow marl, probably Turonian.

Cerithium gracilens, sp. nov.

Testa elongata, turrita, spiræ angulus 14°–16°, *suturæ* 87°: *anfractus multi, complanati, paulum excavati, sutura profunda sejuncti, ternis seriebus tuberculorum ornati tuberculis in serie mediana ceteris multo minoribus: basis anfractus ultimi subconvexa, moderate producta, spiraliter serie una tuberculata; apertura quadrangularis, antice canali angusto terminans.*

An elongated turreted shell composed of numerous flattened volutions, which increase very gradually in length and width. Each of the whorls is ornamented with two rows of rounded and close-set tubercles, adjacent to the suture, which are so prominent as to give to the volutions the appearance of being somewhat excavated. Midway between these rows is a third, made up of much smaller tubercles, less prominent and distinct.

Nineteen specimens, none entire, but the greater number retaining the test.

It may have been such specimens as these, found at Abeih, which Fraas considered to be *C. trimonile* Michelin* (Aus dem Orient, II. Theil, p. 70). That species is very extensively distributed, for besides being known in the Gault of France, it has been recognized by Stoliczka in Southern India. On comparison with Michelin's, d'Orbigny's, and Stoliczka's figures of *C. trimonile*,

* Mém. Soc. Géol., III, p. 100, Pl. xii, fig. 5, 1838.

I am satisfied that the Lebanon specimens before me belong to a species distinct from that. In the first place, they are proportionally longer and narrower than Michelin's species, which has a spiral angle as great as 30° and 32°; while the spiral angle of the shells in hand is never larger than 16°. Again, according to the best description of *trimonile*, that of Stoliczka, the tubercles of the uppermost or posterior row in young specimens are always distinctly divided by a deep groove, while the tubercles in the other two rows approach so near each other that they seem to form short transverse ribs. The anterior row has generally the largest tubercles; but sometimes the tubercles of the two anterior rows are nearly equal, and not so strong as those of the posterior row. Besides the tuberculated ridges, the entire shell-surface is minutely striated. None of the foregoing specifications of Stoliczka's apply to the present species. The younger specimens have the tubercles of the anterior and posterior rows equal in size; but in some of the older, the tubercles of the posterior row become the larger. Nor are the tubercles of either row divided by a groove. The central row always consists of smaller tubercles, much less prominent and distinct than those of the other rows. On the base of the last or anterior whorl is a single row of indistinct tubercles parallel to the other rows. Old specimens show heavy lines of growth upon the sides and base. Coll. Thomson.

Locality and Position. — Probably Abeih or its vicinity. The specimens of this species, like those of *Nerinea gemmifera*, already noticed on page 26, are completely silicified and colored reddish or yellowish by oxide of iron. Fraas represents a splintery limestone bed (*splitterige Kalkbank*) of the Gasteropod zone of Abeih as being most productive of *Cerithia*. Since in limestones the mineralizing factor of fossils is more commonly silex, it is highly probable that these specimens were taken from the limestone layer of the Turonian Gasteropod zone.

UNDETERMINED.

Six casts from the Merrill collection, of which the two in best condition are represented on Plate II by figures 9 *a*, *b*. They seem to be identical with the specimen described and figured by Conrad (Official Report, p. 234, App., Pl. v, fig. 43) as *Cancellaria petrosa*. The casts have a few distant and rather oblique longitudinal ribs, but I find no proof that they belong to the genus *Cancellaria*.

LAMELLIBRANCHIATA.

Corbula aligera, sp. nov.

Plate IV, figs. 6 a, b, c, d.

Testa parva, triquetra, inæquilateralis, clausa; valvula dextra paulo major quam sinistra; postice acuminata, valde angulata; margo anticus insinuatus et infra rotundatus: umbones antemediani, superne appressi et obtusi, involuti, antrorsum intorti: superficies rugis sive varicibus concentricis irregularibus crassis induta: lunula infra illimitata; area cardinalis perangusta, lanceolata, tenuiter excavata. Carina acuta alata, ab umbonibus ad terminationem postero-inferiorem recte decurrens, aream posticam subconcavam costulis radiantibus instructam a lateribus dividit.

Shell small, triangular, inequilateral, perfectly closed at the margins; right valve a little larger than the left, and tightly overlapping it; posteriorly acuminate, strongly angled; anterior margin sinuated above and rounded below: umbones a little in front of the middle point of the shell, obtuse above as if pressed downward, involute and bent forward: surface covered with thick, irregular concentric plaits, or varices: lunule undefined below; hinge area very narrow, lanceolate, slightly excavated. A sharp, wing-like keel, running straight from the beaks to the postero-inferior extremity, divides from the lateral surface the subconcave hinder area, which is marked with radial riblets.

Three specimens. Length, $9\frac{1}{2}$ mm. to $10\frac{1}{3}$ mm.; height, 6 mm. to 7 mm.; thickness, inside of keels, 4 mm. to 5 mm.

The concentric plaits are much narrower than the intervals which separate them. They stop short upon the thin and elevated keel, and are wholly distinct from the more numerous radiating riblets which adorn the nearly flat posterior area. In these unusual features, the species approaches *C. Valdensis* Hebert and Renevier "du Terrain Nummulitique supérieur." (Fossiles du Terrain Nummulitique supérieur des Environs de Gap, des Diablerets, et de quelques Localités de la Savoie. Grenoble, 1854, p. 50, Pl. i, fig. 11.) Coll. Bird.

Locality and Position. — From arenaceous marl, probably Turonian and from the vicinity of Abeih.

Liopistha Libanotica, sp. nov.

Plate VI, figs. 7 a, b, c.

Nucleus ovato-oblongus, æquivalvis, valde inæquilateralis; antice brevior, subventricosus, abrupte declivis ac subrotundatus; depressio lunularis magna, profunda, marginibus valvarum exstantibus medio divisa; postice productus, elevatus, compressus, subtruncatus, paulum hians: umbones antemediani, prominentes, lati, tumidi, incurvi, maxime approximati: superficies concentrice tenuiter sulcata: ligamentum externum: cardo, linea pallii et impressiones musculares ignotæ.

Cast ovately oblong, equivalve, very inequilateral; before shorter than behind, rather ventricose, abruptly inclined and subrotundate; lunular depression large, deep, divided in the middle by the projecting margins of the valves; behind produced, elevated, compressed, subtruncate, slightly gaping: umbones anterior to the middle of the valves, prominent, broad, swollen, incurved, closely approximate: surface concentrically and lightly sulcate: ligament external: hinge, pallial line, and muscular impressions unknown.

Three specimens, internal casts.

Largest:	length,	102 mm.;	height,	80 mm.;	thickness,	56 mm.
One figured:	"	76 mm.;	"	61 mm.;	"	42 mm.
Smallest:	"	73 mm.;	"	52 mm.;	"	36 mm.

As seen from the side, the form and proportions of the specimens strikingly resemble *Liopistha frequens* Zittel, from the Cretaceous of Gosau (first described by Zittel as *Panopæa frequens**), and *Poromya superba* Stoliczka, which, with the other species assigned by that author to the same genus, are conclusively proved by Meek† to belong, not to *Poromya* of Forbes, but to his own *Liopistha*, — a classification which has been adopted by Zittel.‡ In the dorsal view, the casts are seen to be much less ventricose than *superba*, and somewhat less so than *frequens;* while the three species agree in the character of the lunular and dorsal areas, as do the present species and *frequens* in their compressed posterior extremities. Traces of teeth are absent from the casts. A short and rather wide oval cavity or pit, just behind the beaks, seems adapted to the gaping and "short and erect fulcra" (Meek, op. cit.,

* Denkschriften der Kais. Akad., Math. Naturwissensch., XXIV, p. 111, Pl. i, figs. 5 a–g, Wien, 1865.

† Invert. Cret. and Tert. Foss. of Upper Missouri Country, p. 229, Washington, 1876.

‡ Handbuch der Palæontologie, I. Band, 2. Abtheilung, p. 131, München, 1881.

p. 229), — in this species probably continued internally, — which supported the external ligament in the typical *Liopistha*. The lunular region is peculiarly and rather deeply excavated, distinctly circumscribed, and divided in the middle by the projecting anterior margins of the valves. The greatest thickness of the casts is below the umbones, on the vertical line which divides the anterior from the second third; and from the thickest portion the casts thin gradually behind and downwards. The very thin shell gaped slightly behind, and still less, or not at all, in front, while it is evident from one of the two casts, which reflect unmistakably the external characters of the thin test, that the valves were concentrically lightly furrowed and ridged, agreeing in this respect with Meek's section *Psilomya*, *b*.

Conrad's brief description of his *Inoceramus Lynchii* (Official Report, p. 218, Pl. viii, fig. 47), so far as it goes, is not inapplicable to these casts, which may be specifically identical with that; but his figures, also taken from a cast, so imperfectly correspond to our specimens, that on the whole we have thought it best to describe and name anew. Their unlikeness to *Inoceramus* is obvious.

Largest from Coll. Cong. House: the others from Coll. Merrill.

Locality and Position. — Beirût district; from yellow calcareous marl, Turonian.

Ceromya sinuata, sp. nov.

Plate VI, figs. 8 a, b, c.

Nucleus inflato-cordatus, triangularis, æquivalvis (?): *facies anterior lata, truncata, complanato-excavata, a lateribus carina rotundata obscura sejuncta; cavitas lunularis profunda, cordiformis: pars posterior subcompressa, producta, oblique truncata; declivitas cardinalis paululum curvata; margo inferior plus minusve sinuatus; fovea ligamenti angusta et elongata: umbones antemediani, anteversi; apices involuti, attenuati, approximati. Impressiones musculares ac palliales non apparent.*

Cast swollen-cordate, triangular, equivalve (?): anterior face wide, truncate, flatly excavated, separated from the flanks by an indistinct rounded keel; lunular hollow deep and heart-shaped: hinder portion rather compressed, produced, obliquely truncate; hinge-slope slightly curved; the lower margin more or less sinuate; the ligamental furrow narrow and long: umbones antemesial, turned forward; beaks involute, attenuate, approximate. Muscular and pallial impressions not distinguishable.

Three casts. Dimensions of largest (figs. 8 *a*, *b*): length, 35 mm.: height 32½ mm.; thickness, 28 mm.; — of second cast (fig. 8 *c*): length, 27½ mm.; height, 25 mm.; thickness, 23 mm.

The largest specimen is unsymmetrical, owing partly to distortion through pressure, but perhaps in part to original inequality of the valves. In the other two examples, the beaks, which in this have been forced into contact, are two millimeters asunder. The flattened anterior face answers well to Agassiz's diagnosis of the genus, and to figures of several of his species. The deep dorsal depression between the umbones is analogous to the corresponding part in several recognized species of *Ceromya*. The hinge was undoubtedly edentulous. The three casts bear crowded concentric striæ, too indistinct to be well figured, but very perceptible. These and the absence of any traces of muscular and pallial impressions indicate that the test was very thin. Stoliczka identifies a single species of *Ceromya* in the Cretaceous of Southern India.

Conrad's description and figures of *Opis orientalis* (Official Report, p. 231, App., Pl. ii, figs. 10 *a*, *b*) may possibly refer to this species, but are vague and unsatisfactory. Coll. Thomson.

Locality and Position. — Probably from Beirût district, and from the Turonian.

Pholadomya depacta, sp. nov.

Plate VI, figs. 6 a, b.

Nucleus ovato-oblongus, æquivalvis, perinæquilateralis, costulis radiantibus angustis circiter quindecim notatus: pars antica brevissima, obtusa, postica dilatata, compressiuscula, oblique truncata ac mediocriter hians: umbones inflati pæne terminales, depressi, inter se attingentes: margo ventralis arcuatus, dorsalis oblique retrocurvatus: lunula absens; area cardinalis anguste lanceolata.

Cast ovate-oblong, equivalve, extremely inequilateral, bearing about fifteen narrow ribs radiating from the beaks: anterior portion very short and obtuse; hinder part widened, somewhat compressed, obliquely truncate and at the truncated edge moderately gaping: the inflated umbones almost terminal, depressed, contiguous: ventral margin arcuate; dorsal margin slantingly curved backward: lunule wanting: posterior area narrowly lanceolate.

Single specimen, a cast. Length, 48½ mm.; height, 44 mm.; thickness, 26 mm.

The valves at their anterior junction form a projection, which is conspicuous just below the lunular area, but farther down disappears, seemingly in consequence of flattening over a small space through pressure, which gives a somewhat truncate appearance to the front margin. The slight rim of the lanceolate cardinal area has been removed upon the right side. The radiating ribs, though considerably worn, are still plainly visible, but no trace of concentric lines or wrinkles of growth can be distinguished.

The cast most nearly resembles *Ph. rostrata* Matheron, as described and figured by Zittel (Die Bivalven der Gosaugebilde in den Nordöstlichen Alpen, Denkschriften Kais. Akad., Math. Naturwissensch., XXIV, p. 115, Pl. ii, figs. 2 *a–c*, 1865). It is, however, proportionally higher, is more ventricose, and lacks the *area posticalis profunda, angulo elevato circumscripta*, which is very marked in that species. But for the difference in this last respect, I should regard the two as identical, as they indeed may prove to be upon the accumulation of more material.

Comparison with Conrad's type may show this to be his *Ph. decisa* (Official Report, p. 217, Pl. vii, fig. 44), which was described and figured from a single specimen found at Bhamdûn, in the Beirût district. But I am unable to make the two to be one and the same species on the evidence of Conrad's figure and description. Coll. Merrill.

Locality and Position. — Beirût district; from a highly ferruginous Turonian deposit.

Cytherea (Callista ?) Libanotica, sp. nov.

Plate IV, figs. 3 a, b, c.

Nucleus ovato-triangularis, inæquilateralis, tumidior, antice breviter et late rotundatus, postice oblique productus, cuneiformis, subattenuatus: margo inferior convexus, extremitatem posteriorem versus fere rectus seu paululum insinuatus: margo lunularis concavus, arealis rectiusculus; depressio lunularis profunda, ovato-elongata, infra acuta, marginata; depressio arealis insignis, lanceolata, marginibus rotundatis terminata: umbones antemediani, prominuli, incurvi: cicatrix muscularis antica conspicua, postica cerni non potest.

Cast ovate-triangular, inequilateral, rather swollen, shortly and widely rounded before, behind obliquely produced, wedge-shaped, somewhat attenuate: lower margin convex, but toward the posterior end almost straight or very slightly sinuated: lunular margin concave, that of the area nearly rectilinear: lunular depression deep, ovate-elongate, sharp below; depression

corresponding to the area marked, lanceolate, limited by rounded margins: umbones ante-mesial, rather prominent, incurved: anterior muscular scar conspicuous, the posterior one not to be distinguished.

Four specimens, casts. Dimensions of those figured: —

Largest: length, 84 mm.; height, 71 mm.; thickness, 45 mm.
Smallest: " 33 mm.; " 25 mm.; " 17½ mm.

The specimens seem to belong to a species hitherto unnamed, and to be of form so peculiar that it cannot be mistaken. Comparison with an internal cast taken for the purpose, in plaster, from *Callista squalida* Sow., leaves very little doubt that the species is rightly to be referred to *Callista*, which, with Stoliczka and Zittel, I prefer to consider a subgenus of *Cytherea*.

The very brief description of *Venus indurata* Conrad (Official Report, p. 219, Pl. ix, fig. 53) corresponds fairly to these casts, but the figure cannot be recognized as representing them.

Collections Merrill and Congregational House.

Locality and Position. — Beirût district; Turonian.

Isocardia Merrilli, sp. nov.

Plate V, figs. 2 a, b, c.

Nucleus oblique trigonus, cordiformis, summe tumidus, æquivalvis, inæquilateralis; extremitas anterior brevis, angulata, plus minusve truncate rotundata; margo ventris lente arcuatus; extremitas posterior ab umbonibus cito planeque declivis et supra angulum infero-posteriorem truncatus: gibbositas maxima paulo postmediana, super umbones deorsum et retrorsum adversus marginem infero-posteriorem decurrens: umbones prorsum inclinati, subterminales, inflecti, ad apices acutos late separati: regio lunularis excavato-cordata, dilatata, ei Isocardiæ cordis Linn. *persimilis: linea cardinalis ut in nucleis Isocardiæ typicæ solet: prominentiæ impressionibus musculorum anteriorum, pallii lineæ et fovcolarum suprajacentium congruentes altæ et generi propriæ.*

Cast obliquely triangular, heart-shaped, extremely tumid, equivalve, inequilateral; anterior extremity short, angulated, more or less truncately rounded; ventral margin gently arcuated; posterior extremity rapidly and flatly sloping and truncate above the angle formed by the ventral and posterior margins. The greatest gibbosity is a little back of the middle, beginning upon the umbones and extending along them downward and

backward towards the lower-posterior margin: umbones inclined forward and subterminal; beaks inflected and widely sundered at their apices, which are acute and in the complete shell were probably directed upward. The lunular region is excavated into a wide cordate pit, which agrees closely with that of the recent *Isocardia cor* Linn. The hinge line is represented by a thin sinuous ridge similar to that which may be seen in an artificial cast of *I. cor*. Elevations corresponding to the anterior muscular and pallial impressions, and to the little pits above the latter, show all these to have been deep and characteristic of the genus.

The four specimens, all interior casts, differ from each other but slightly, except in the shape of the posterior part, which is somewhat variable in its proportions.

The dimensions of the specimen represented by figures 2 *a*, *b* are: length, 61 mm.; height, 73 mm.; thickness, 72 mm.; — of that shown by figure 2 *c*: length, 62½ mm.; height, 64 mm.; thickness, 71 mm.

Collections Merrill, Congregational House, and Thomson.

Locality and Position. — Beirût district; probably from the fourth of Fraas's nine zones, that of the Turonian Cardium bed, which abounds in casts of this genus.

Cyprina orientalis, sp. nov.

Plate V, figs. 3 a, b.

Nucleus oblongus, inflatus, æquivalvis (?), *inæquilateralis: latus anticum breve, sub umbonibus emarginatum et infra emarginationem paulo productum ac subrostratum; regio lunularis valde excavata: latus posticum elongatum, rotunde truncatum; area angusta, profunda, haud marginata: umbones admodum prominentes, prorsum inclinati; apices magni, crassi, retusi, incurvi, approximati: margo ventris subrectus: prominentiæ impressionibus musculorum anteriorum et pallii congruentes insignes.*

Cast oblong, inflated, equivalve (?), inequilateral: anterior side short, emarginate beneath the umbones, and below the emargination slightly produced and subrostrate; lunular region strongly excavated: posterior side elongate, roundly truncate; area excavated but not defined by a border: umbones very prominent and inclined forwards; beaks large, swollen, blunt, incurved, approximate: ventral margin almost straight: elevations corresponding to the anterior muscular and pallial impressions protuberant.

Single specimen, a cast. Length, 84 mm.; height, 69 mm.; thickness, 64 mm.

From figure 3 *b*, which is accurately drawn, the cast would seem to be inequivalve. Careful inspection, however, leads to the conclusion, that a force acting from above has depressed the right beak and pushed it into contact with the left, — the two originally having been somewhat separated in the cast. It is probable that the complete shell — which the deep muscular and pallial impressions show to have been thick — was equivalve, and that the beaks were closely approximate, if not actually contiguous.

This species resembles in some degree the Cretaceous *C. intermedia* d'Orb., and *C. Valangiensis* Pict. and Camp., though distinct from both. Possibly it may be identical with *Isocardia crenulata* Conrad (Official Report, p. 215, Pl. iv, fig. 26), described from "casts, all more or less distorted," of which the author furthermore says, "The figure represents the original form as nearly as I could restore it." Neither the description nor the figure applies with any certainty to the specimen here considered.

Fraas (Aus dem Orient, I. Theil, p. 94) regards *Isocardia crenulata* Conrad as being *Cyprina inornata* d'Orb. Our cast is certainly distinct from *C. inornata*. Coll. Merrill.

Locality and Position. — Beirût district; probably from the zone of the Cardium bed.

Cyprina (Venilicardia?) Abeihensis, sp. nov.

Plate IV, figs. 2 a, b, c.

Testa trigono-cuneata, crassiuscula, inæquilateralis, tumida; antice ad marginem lunularem leviter insinuata et infra breviter rotundata: margo dorsi posticus primum curvatus deinde rectilineus et rapide declivis; extremitas postica subcaudata et oblique truncata: margo ventris arcuatus et pone vix flexuosus: umbones subterminales, angulati, acuti, contigui, antrorsum valde inflexi: lunula fere plana, nisi supra vix excavata, verticaliter rotundato-elongata, margine acuto circumscripta: arca cardinalis lanceolata, profunda, carinis subacutis terminata; extra carinas arca planata a lateribus angulo obtuso obliquo disjuncta: superficies concentrice tenereque striata, striis nonnullis incrementi fortioribus lamellisque seu varicibus circiter octo apud umbones instructa: cardo, ut mihi videtur, dentibus tribus primariis et certe in valva dextra uno laterali, postico, elongato, recto armatus: impressiones musculares evidentes, haud profundæ: margo internus tenuis, non vero crenulatus.

Shell cuneiform-triangular, moderately thick, inequilateral, tumid; in front at the lunular margin lightly sinuate and below abruptly rounded: hinder dorsal margin at first curved, then rectilinear and rapidly sloping; posterior

extremity subcaudate and obliquely truncate: ventral margin arcuate and behind slightly flexuous: umbones subterminal, angulated, sharp, contiguous, strongly turned forward: lunule almost flat, slightly excavated at the upper part, vertically roundly-elongate, bounded by a sharp margin: cardinal area widely lanceolate, deep, limited on each side by a rather sharp ridge or keel; outside of the ridges, on each side, a flattened area, separated from the convex portion of the valve by an obtuse ridge running from the beak to the postero-inferior extremity: surface marked with fine concentric striæ and distant coarser lines of growth, all of which become heavier on the flat umbonal declivity, the striæ being replaced upon the beaks by about eight low and regular varices: hinge apparently armed with three primary teeth, and on the right valve with a distinct, remote posterior lateral tooth, straight and elongate: muscular impressions clearly marked, but not deep: internal margin thin and not crenulated.

Two specimens: —

Larger:	length, 51 mm.;	height, 46 mm.;	thickness, 36 mm.	Coll. Bird.
Smaller:	" 44½ mm.;	" 38½ mm.;	" 30 mm.	Coll. Merrill.

It seems probable that the species figured by Fraas under the name *Astarte Libanotica* (Aus dem Orient, II. Theil, p. 45, Pl. iii, figs. 1 *a*, *b*), and said by him to be "one of the commonest shells in the horizon of the sandstone," is identical with this. But his figures represent the ante-umbonal portion as considerably longer, the hinder extremity rounded rather than truncate, and the posterior umbonal slope as wanting the flat surface which is present in our specimens, and is bounded on one side by an obtuse ridge running from each beak to the posterior-basal angle, and on the other by the sharp ridge which limits the cardinal area. Our specimens are alike in form and proportions, and while they and Fraas's figures may represent divergent forms of one and the same species, yet since the uncertainty in this respect is in no degree removed by any verbal description, and as we cannot regard the shell as an *Astarte*, we feel warranted in describing and naming it anew.

Fraas's only semblance of description is contained in the following passage: "Characteristic of *Astarte Libanotica* are six to eight strong Astarte-wrinkles next to the umbones, but which farther upon the shell flatten out, so that it appears nearly smooth. Without the aforesaid ribs, peculiar to the genus *Astarte*, from the aspect of the shell one would sooner think of *Venus* and its related genera. Whether the margin of the shell is notched or smooth, unfortunately I cannot affirm from any of the specimens."

Although both our specimens allowed the separation of their valves, only part of the internal characters were brought to light. The cardinal teeth are completely silicified, and instead of separating were cleft, in the larger and finer specimen (the one figured) leaving a surface so irregularly fractured that the nature of this portion of the hinge is not discernible. From the left valve of the smaller enough can be distinguished to make it tolerably certain that the hinge was longer and more complicated than the short and simple hinge of *Astarte*. In the right valve of both specimens a very distinct, but peculiar, long, straight, remote, posterior lateral tooth is present, a character never found in Astarte. The lateral tooth of the left valve is not well preserved in either case. Being thinner than that of the right, and overlapping it externally, the tooth was injured in separating the valves. The pallial line could not be freed from hard stony deposit, and remains unknown. The muscular impressions are shallow, and with the thin and smooth inner margins of the valves, which show no traces of crenulation but have a sharp chisel-edge, they coincide closely with *Cyprina Islandica* Linn. Such a marginal edge is exceptional in Astarte.

Calling in the aid of external characters in the determination, it will be observed that the shells of all recent, as well as of all fossil species of Astarte to which doubt in respect to their classification does not attach, are considerably flattened, while the specimens in question are decidedly ventricose. And though their umbonal wrinkles or varices are very like those of Astarte, yet instead of covering the whole surface of the shell and growing stronger towards the ventral margin, as in most species of that genus, in these fossils the wrinkles are found only upon the beaks. But for the conspicuous external ligament, the wrinkles would suggest rather that the species belongs to *Crassatella*, in some recent species of which, as *C. Kingicola* Lam. and *C. undulata* Sow., a few strong wrinkles similar to those of our fossils appear upon the beaks and are confined to them.

Comparing the present species with *Cyprina* (*Venilicardia*) *Ligeriensis* d'Orb. (Paléont. Franç., Terr. Crét., III, p. 103, Pl. cclxxv), one of the most characteristic species of the subgenus *Venilicardia*, it will be found that the two have lunules, areas, umbonal slopes, and in fact most of their parts, strikingly similar, the chief external difference, aside from the umbonal plaits, being that the posterior dorsal slope of *Ligeriensis* is less rapid, producing a hinder extremity higher than that of the subcaudate *Abeihensis*.

Typical specimens of *Cyprina rostrata* Sow. (Trans. Geol. Soc. Lond., [2,]

IV, p. 341, Pl. xvii, figs. 1 *a*, *b*, *c*, 1836) from the Greensand of Blackdown, when compared with ours, show a resemblance equally striking. They too have, upon the beaks, concentric wrinkles similar to those of *Abeihensis*, but smaller; and the two species in other respects differ little externally, except that the anterior part of *rostrata* is somewhat longer, and its lunule deeper, though margined in the same way.

While inclined to believe that this species belongs to the family *Cyprimdæ*, I refer it with less confidence to *Venilicardia*, and not without the feeling that it may prove to be a *Cypricardia*.

Locality and Position. — Vicinity of Abeih. Fraas makes his *Astarte Libanotica* to be one of four characteristic fossils of the Sandstone stage of the Cenomanian (see pp. 6, 7). If not identical with *Libanotica*, this species, which was taken from sandstone, probably belongs to the same horizon.

Cardium (Acanthocardia) Syriacum Conrad.

Plate III, figs. 7 a, b, c.

Cardium Syriacum Conrad, 1852, Official Report, p. 217, Pl. vii, fig. 45.

Nucleus oblique cordiformis, inæquilateralis, altitudine longitudinem multo superante; antice ad marginem lente curvatus, postice subrectus: declivitas posticalis abrupta, lata, applanata, sulcis umbonalibus incavata; umbones tumidi porrecti; apices antemediani, attenuati, acuminati, approximati (in testa sane contigui): regio lunularis impressionibus profundis dentium lateralium anteriorum notata; lunula magna, cordiformis, paululum impressa, sulco lævi terminata.

Internal cast obliquely heart-shaped, inequilateral, much higher than long; gently curved at the front margin, the hinder being nearly straight: posterior slope abrupt, broad, flattened, grooved with furrows on the umbones; umbones swollen, long; beaks placed before the middle, attenuate, pointed, approximate (in the complete shell doubtless in contact): lunular region marked by deep impressions left by the anterior lateral teeth; lunule large, cordate, superficial, bordered by a slight furrow.

Twelve casts. Dimensions of the specimen figured, and of a larger imperfect cast: —

Of the former:	length, 29½ mm.;	height, 34 mm.;	thickness, 27 mm.
Of the latter:	" 33 mm.;	" 40 mm.;	" 32 mm.

Although Conrad's description is inadequate, yet so marked is the agree-

ment in outline between the casts and his figure, taking the side view, that the propriety of referring the fossils to the species named above is manifest. But the figure must have been drawn from a cast on which the ridge caused by the filling of the posterior gape of the valves had been worn away. This, as seen in our figure, presents at the margin a straight line running obliquely downward from the obtuse angle which it forms with the hinge line. The posterior view shows curved grooves proceeding from the beaks downward and inward to the mesial ridge. These are imprints left by internal umbonal ridges, such as occur in the recent *C. consors* Sow., *C. isocardia*, Linn., and other species of the subgenus *Acanthocardia*, which ridges stamp upon plaster casts of their interiors like grooves, but less deeply impressed. The species just named, however, have no defined lunule, but their internal casts show beneath the beaks, in front, a widely cordate impression, left by the large anterior lateral teeth. The corresponding cavity in the Lebanon casts is due to a like cause, and outside of it is seen the border of a "lunule large and cordate," but very feebly impressed. Two of the casts clearly show the presence of thick-set, narrow radiating ribs. Coll. Thomson and Merrill.

Locality and Position. — Beirût district; probably from the zone of the Cardium bed.

Cardium crebriechinatum Conrad.

Cardium crebriechinatum Conrad, 1852, Official Report, pp. 217 and 231, Pl. vi, figs. 41–43, Pl. xv, fig. 77, and App., Pl. ii, fig. 16.

Two specimens, one with test, and nearly entire; the other an imperfect cast.

Fraas doubts the classification of this species as a *Cardium*, and is inclined to consider it to be a *Cardita*, — on what ground is not evident. Lartet thinks it may be identical with *C. sulciferum* Coquand (Géol. et Paléont. de Constantine, p. 206, Pl. x, figs. 15, 16). The forms of the two species are indeed very similar, and both are covered with radiating ribs; but upon *sulciferum* (which is much the larger of the two) the ribs are wide, while upon *crebriechinatum* they are much more numerous and very narrow. Coll. Thomson.

Locality and Position. — Found at Abeih by Fraas, and by him referred to the Gasteropod zone of that vicinity.

Cardium (Protocardia) Hillanum Sowerby.

Cardium Hillanum Sowerby, 1813, Min. Conch. Gr. Brit., I, p. 41, Pl. xiv, fig. 1.
Cardium biseriatum Conrad, 1852, Official Report, p. 216, Pl. vi, figs. 38–40.
Cardium bellum Conrad, 1852, Official Report, p. 225, App., Pl. i, fig. 3.

Fifteen specimens, all casts. Though entirely devoid of test, they are easily identified by their form alone. Impressions from some of the shell markings are often retained by the casts. Merrill, Thomson, and Congregational House collections.

Locality and Position. — Beirût district; probably from the Turonian Cardium bed.

Cardium (Protocardia) Judaïcum, sp. nov.

Plate IV, figs. 5 a, b, c, d.

Testa subquadrata, subæquilateralis, paulo longior quam altior, moderate inflata; margo anticus rotundatus, posticus oblique truncatus, superne rectiusculus: umbones tumidi, obtuse angulati, postice concavi; apices fere in media testa siti, prominuli, subacuti, incurvi, arte approximati: superficies lateralis varicibus concentricis, regularibus, plano-convexis, lævibus, quam spatia interposita latioribus, circiter triecnis obtecta; superficies postica costis radiantibus angustis, spinulis et lamellis tenuissimis ornatis, duodenis munita: margo posticus usque ad angulum postero-ventralem dentatus. Signa interna ignota.

Shell subquadrate, subequilateral, a little longer than high, moderately inflated; anterior margin rounded; posterior margin obliquely truncated, above nearly straight: umbones swollen, obtusely angled, more or less concave behind; beaks nearly mesial, somewhat prominent, rather sharp, incurved, closely approximate: lateral surface furnished with about thirty regular concentric varices which upon their faces are flatly convex, smooth, and wider than the furrows between them; posterior surface marked by twelve narrow radiating ribs, which are studded with spinules set at equal distances, and are crossed by extremely delicate lamellæ: posterior margin toothed as far down as the postero-ventral angle. Characters of interior unknown.

Dimensions of the entire specimens: —

Larger: length, 24½ mm.; height, 22 mm.; thickness, 18 mm.
Smaller: " 23 mm.; " 21 mm.; " 15 mm.

The three examples of this species are two entire shells retaining the test complete, and a single right valve. In the smaller entire one the surface at the posterior umbonal slope is so remarkably preserved that the minute spinules which stud the radial ribs are in part retained, and with the delicate lamellæ which cross the ribs are conspicuous under the lens. In some of the spaces between the ribs the lamellæ have all their original sharpness and perfection. Of the same specimen, shown in figs. 5 *b*, *c*, the beaks have been pressed into actual contact, while in the normal example, of which a right side view is given in fig. 5 *a*, they are separated by a small space.

Lartet (op. cit., p. 130, Pl. xi, fig. 5, and Pl. xii, fig. 9) figures, without description, under the name *Cardium Hillanum* Sow., var. *Moabiticum*, a shell which, as figured, agrees essentially with immature individuals of the typical *Hillanum* from the Blackdown Hills of Devonshire. The three specimens upon which the present species is based are obviously distinct from *Hillanum*. Comparison with a full series of the species last named from the Blackdown Greensand, and with many casts of the same from Lebanon, shows the following differences. In the side view, the outline of *Hillanum* is rotundate-cordate; of this, subquadrangular. The concentric markings of the former are numerous striæ with very small intervening ridges; of the latter, wide and flattish varices, separated by well impressed furrows. The posterior umbonal slope of *Hillanum* is always flattened, while that of the species in hand is somewhat concave, and near the posterior margin is suddenly compressed, the compressed part including a straight and very gently descending hinge line.

Nor is this species *C. bifrons* Reuss (Kreideschichten in den Ostalpen, p. 145, Pl. xxviii, fig. 19, 1854), which is a variety of *Hillanum*. Our fossils most nearly resemble *C. Vattoni* Coquand (Géol. et Paléont. de Constantine, p. 207, Pl. xi, fig. 5), which is readily distinguishable by having tubercles upon its twenty posterior radiating ribs.

Locality and Position. — The single valve, from the Merrill collection, was taken from ferruginous and arenaceous marl, and therefore cannot be referable to the Cardium zone of the Turonian, which is made up of brown limestone and contains only casts of various species of Cardium. The entire specimens, from the Bird collection, are apparently from the same kind of rock, which seems to be identical with the arenaceous marl of the Gasteropod zone, already noticed. As, according to Fraas, that zone yields fairly preserved specimens of *C. Hillanum*, it is not improbable that this species is from the same horizon.

Gonodon? hebes, sp. nov.

Plate IV, figs. 1 a, b, c, d.

Testa subquadrata, ventricosa, crassiuscula, paulum inæquilatera, rugulis incrementi modicis irregularibus obducta: latus anticum perbreve, truncatim rotundatum, posticum longius, altum, rotundato-angulatum, fere verticaliter truncatum: umbones antemediani, turgidi, retusi, incurvi: lunula nulla aut parva et illimitata: specimini unici umbonum cacumina absumpta; area ligamentalis cardinisque pars magna exesæ: utriusque valvæ dens cardinalis anticus trigonus, robustus, latus, superne profunde concavus; margines intus læves. Ceteræ notæ cerni non possunt.

Shell subquadrate, ventricose, moderately thick, somewhat inequilateral, covered with irregular wrinkles of growth of inconsiderable size: anterior side very short, truncately rounded, hinder side the longer, high, obliquely angled by an obscure rounded umbonal ridge, almost verticaly truncated: umbones antemesial, swollen, blunt, incurved: lunule none or small and undefined: tips of umbones of the single specimen decayed; ligamentary area and larger part of the hinge removed by corrosion; under the beak of each valve a wide, strong triangular tooth, deeply concave above and prolonged in the direction of the longitudinal axis of the shell. The other characteristic marks cannot be distinguished.

Single specimen, with test. Length, 37 mm.; height, 34 mm.; thickness, 28½ mm.

Of the solitary example, the beaks in part, the whole area, and the greater portion of the hinge have been removed by decay. Beneath the beak in each valve remains a remarkably prominent triangular tooth, deeply hollowed upon its inwardly sloping wide upper face. These teeth are quite unlike any others of which I have knowledge, and it is difficult to give a correct idea of them either by a figure or in words.

The peculiar form, together with the concentrically wrinkled surface and the somewhat enlarged lunular margin, indicates the relationship of this shell to that group of the *Lucinidæ* to which the genus *Unicardium* belongs. The abnormal development of the two remaining hinge-teeth forbids that it should be referred to any genus of that group except *Gonodon*. Since the work* which contains Schafhæutl's original diagnosis of that genus is wanting in the libraries of Cambridge and Boston, I have it only as given by

* Süd-Bayerns Lethæa Geognostica, 1863.

Stoliczka and Zittel, briefly, and as respects the teeth not very clearly. I have therefore given a generic name to this shell with much doubt, especially as *Gonodon* has hitherto been known only from Jurassic strata. Coll. Merrill.

Locality and Position. — Beirût district; from a yellow arenaceous marl, probably Turonian.

Cardita lacunar, sp. nov.

Plate V, figs. 1 a, b, c, d, e.

Testa parva, orbiculato-quadrangularis, paulo longior quam altior, tumida, inæquilateralis, umbonibus obliquis incurvis approximatis antemedianis instructa: margo anticus insinuatus, rotundatus, posticus abrupte truncatus, cardinalis retrorsum lente declivis, ventralis æqualiter arcuatus: superficies costis radiantibus quaternis denis compressis squamosis eleganter insculpta; squamæ suberectæ, rotundæ, imbricatæ; interstitia lata, profunda, in valva sinistra duo posteriora lamellis transversis specie lacunarium divisa: lunula parva, cordiformis utrinque cavata, medio parum elevata: signa interna incognita.

Shell small, roundish-quadrangular, a little longer than high, tumid, inequilateral, furnished with oblique, incurved, closely approximate antemesial umbones: anterior margin insinuate, rounded, the posterior one abruptly truncate, the hinge margin gently sloping backward, the ventral regularly arcuated: surface elegantly sculptured with fourteen radiating, compressed scaly ribs; the scales suberect, round at the end, imbricate; interspaces of the ribs wide and deep, the hinder two upon the left valve divided by transverse lamellæ after the manner of lacunaria: lunule small, cordate, excavated on each side, elevated in the middle. Characters of the interior unknown.

Five examples, almost uniform in size, and all retaining the test entire. Length, $8\frac{1}{2}$ mm.; height, $7\frac{1}{2}$ mm.; thickness, 6 mm.

In all the specimens the posterior cardinal margin of the left valve is conspicuously higher than that of the right; and the interspace of the hindermost two ribs of the same valve is divided by delicate and flexuous transverse lamellæ into four-sided pits, panels, or compartments, widest in proportion to their length toward the beaks and narrowing downward. This structure, which suggested the specific name, is upon the right valve barely indicated, never complete. Coll. Bird.

Locality and Position. — Probably from the vicinity of Abeih, and from the Turonian marl.

Hippurites plicatus Conrad.

Plate III, fig. 8.

Hippurites plicatus Conrad, 1852, Official Report, p. 234, App., Pl. vii, fig. 49.

Two specimens, apparently of this species. The one figured is a free lower valve: height, 68 mm.; greatest width, 45 mm. The other is a cluster of aggregated individuals, upon one of the imperfect shells of which a single upper valve is present. This is in place, and, so far as it is distinguishable in the mass, has the general form and about one fourth the height of the figured lower valve, with its apex central and directed upwards. Coll. Merrill.

Locality and Position. — Beirût district; probably from the same horizon as the species next following.

Hippurites Lewisii Fraas.

Hippurites Lewisii Fraas, 1878, Aus dem Orient, II. Theil, p. 74, Pl. v, figs. 5 *a*, *b*.

A single lower valve, entire and answering fairly to Fraas's description and figures. Height, 65 mm.; greatest width, 60 mm. Whether this and *plicatus* are distinct species may perhaps be doubted. Coll. Thomson.

Locality and Position. — Probably the Beirût district; assigned by Fraas to the Cardium bed of the Turonian (see pp. 6, 7).

Trigonia Syriaca Conrad.

Trigonia Syriaca Conrad, 1852, Official Report, pp. 214 and 232, Pl. iii, figs. 19, 20, 21, 23, and App., Pl. iv, fig. 26.

Trigonia Syriaca Fraas, 1878, Aus dem Orient, II. Theil, p. 43, Pl. iii, figs. 2–5.

Seven specimens. Three with both valves nearly entire; one single right valve; three casts. Fraas's figures of the exterior of this species are far better than Conrad's.

The best shells and casts — two of each — are from a private collection of Professor Louis Agassiz, and are labelled only "Lebanon." The others are from the Merrill collection.

Locality and Position. — Probably from the Beirût district. Fraas styles this the "leading fossil" of the Cenomanian Sandstone.

Nucula (Cucullella?) Palæstina, sp. nov.

Plate VI, figs. 5 a–i.

Testa parva, subcylindrata, duplo longior quam altior, maxime inæquilatera et ventricosa, crassitudo altitudini fere adæquans; antice attenuata submucronata; extremitas postica paulo compressa, acuta; margo dorsi antice insinuata, postice paululatim declivis; margo ventris antice subsinuata, postice æqualiter arcuata: umbones humiles inconspicui, antrorsum inclinati: lunula superne angulo acuto apicum definita, inferne vix limitata: superficies striis concentricis tenuibus confertissimis notata: cardo multidenticulatus; linea cardinalis obtusangula.

Shell small, subcylindrical, twice as long as high, exceedingly inequilateral and ventricose, the thickness almost equalling the height; attenuate and submucronate in front; hinder extremity a little compressed, sharp; dorsal margin sinuated before, behind very gradually sloping; ventral margin subsinuate in front, posteriorly regularly arcuated: umbones low, inconspicuous, inclined forward: lunule defined above by the acute angle formed by the beaks, below scarcely limited: surface marked by delicate concentric striæ, very closely set; hinge multidenticulate; hinge-line obtusely angled.

Thirty-three specimens, all with test entire. Length, 13 to 15½ mm.; height, 7½ to 8½ mm.; thickness, 7 to 8⅓ mm.

Of the whole number only a single specimen allowed the test to be removed, leaving the cast with all its markings distinct, except the anterior slope of the hinge line, which is partially obscured, but evidently toothed. The muscular impressions are shown to be deep and somewhat angular, the pallial line simple and rather distant from the ventral margin. The anterior boundary of the umbones is more conspicuously angular and prolonged in the cast than in specimens covered by the test. A little behind the beaks of the cast a groove runs from the dorsal margin almost vertically downward (slightly backward) about 2 mm. It is divided lengthwise into two grooves by a ridge along its middle. In *Cucullella* M'Coy,* according to the diagnosis, "a strong internal septum [clavicle] extends from before the beaks to the posterior margin of the anterior adductor, forming a deep slit in the casts." Our cast indicates the existence of a channelled septum (within the test)

* Zittel (Handbuch der Palæontologie, I. Band, 2. Abtheilung, p. 53) regards *Cucullella* M'Coy (Annals and Magazine of Natural History [2], VII, p. 50, 1851) and *Cleidophorus* Hall (Palæontology of New York, I, p. 300, 1847) as identical. Both are palæozoic.

which runs almost vertically downward from a point a little *behind* the beaks. Shall the diagnosis of *Cucullella* be changed to include the present species, or shall the species be excluded from the group?

Zittel (Die Bivalven der Gosaugebilde in den Nordöstlichen Alpen, Wiener Akademie, Denkschriften Math. Naturwiss., XXIV, pp. 162–164, 1865), Meek (Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country, p. 98, 1876), and some others, following Deshayes, have considered the shorter and generally truncated side of the shell of *Nucula* to be the posterior rather than the anterior part, the beaks to be directed backward, and what seems to be the lunule as really corresponding with the escutcheon (area) of other types. But Zittel (Handbuch, I. Band, 2. Abtheilung, p. 52, 1881) has returned to the older and more common view, which we have followed in our description of this species.

N. cylindrica M'Coy (Synopsis of Carboniferous Limestone Fossils of Ireland, p. 69, Pl. xi, fig. 26, 1844) is a closely related species. Finally, *N. submucronata* Conrad (Official Report, p. 213, Pl. ii, fig. 14) based upon a cast much larger than our specimens, may possibly be identical with this species. But as his figure and description of the cast do not represent an internal ridge to be present, and as specimens with the test were unknown to Conrad, we have regarded it as necessary to publish our examples under a new name. Coll. Bird.

Locality and Position. — The cast above mentioned and specimens broken to show the mode of mineralization have the same peculiar pyritiferous composition which was found in the Jurassic Ammonites from the Ornati Clay of Mejdel esh Shems. Of the different collections considered in this paper, no fossils known to be Cretaceous exhibit this kind of mineralization. We may therefore infer that the species is probably from the locality and formation which furnished the Ammonites referred to.

Leda decussata, sp. nov.

Plate VI, figs. 4 a, b, c.

Testa ovato-subtriquetra, antice inflata, postice attenuata, rostrata; umbones parvi, incurvi, contigui, mediam pæne testam tenentes; lunula acute elliptica, fere plana, obscure marginata; area profunde excavata, lira edita lata rotundata terminata: angulus cardinalis obtusus: superficies striis concentricis regularibus creberrimis, aliis radiantibus minutis decussatis, insculpta, sub vitro venusta.

Shell ovately triangular, inflated in front, behind attenuate, rostrate: umbones nearly mesial, small, incurved, contiguous; lunule sharply elliptical, obscurely margined; area deeply excavated, bounded by a rounded, broad, elevated ridge; angle of hinge line obtuse: surface engraved with crowded regular concentric striæ decussated by minute radial striæ, and presenting a beautiful appearance under the lens.

Three specimens. Dimensions of that which is in best condition, and figured: length, 12 mm.; height, 8 mm.; thickness, $6\frac{1}{2}$ mm.

This species in form and superficial markings so closely resembles *L. venusta* Sauvage and Rigaux (Journal de Conchyliologie, XIX, p. 356, 1871; XX, p. 180, Pl. xi, fig. 7, 1872), from the *Kimmeridgien moyen de Brèquerecques*, that in the outset I was strongly inclined to look upon it as a variety of *venusta*. But on further examination it seems necessary to set it apart as a distinct species, on account of the following differences. The French specimens are smaller, their three dimensions being given respectively as 7, 4, and 3 mm.; they have the anterior margin rounded, and the surface of the sides *radiatim costellata et concentrice striata* (op. cit., XIX, p. 356), or, *ornée de côtes rayonnantes nombreuses et de stries concentriques* (op. cit., XX, p. 181). The Lebanon shells, on the other hand, have their dimensions about twice greater than those of *venusta:* viz. 12, 8, and $6\frac{1}{2}$ mm.; the front margin slopes in a nearly straight line; and the surface is engraved with close-set, well-impressed concentric striæ, crossed, not by *costæ* nor *costellæ*, but by radial striæ so delicate as to be visible only with aid of the lens. So also the Jurassic *L. lacryma* Sow. sp., has very nearly the form of this species, but is distinguished from it in being smaller, more prolonged posteriorly into a narrow rostrum, and in having its surface marked with "concentric striations, rather remote, and faintly impressed, sometimes undistinguishable" (Morris and Lycett, Mollusca from Great Oölite, Part II, p. 53, Pl. v, figs. 15, 15 *a*, 1853). Coll. Bird.

Locality and Position. — Fraas records from the Ornati Clay of Mejdel esh Shems, under the name of *Nucula lacryma* Sow. (Jahrbuch für Mineralogie, etc., 1877, p. 27, and Aus dem Orient, II. Theil, p. 19, 1878), a species which in all probability is the one here described. The general similarity of the two species has already been noticed above. One of our three specimens has the test partly broken away, showing within a cast having the pyritiferous composition mentioned in connection with the species last described. For reasons there and here stated, it is probable that these specimens of Leda are from the Ornati Clay of Mejdel esh Shems.

Cucullæa (Trigonoarca) Ligeriensis D'Orbigny sp.

Arca Ligeriensis D'Orbigny, 1844, Paléont. Franç., Terr. Crét.., III, p. 227, Pl. cccxvii.

A single internal cast, whose identity is proved by comparison with several excellent and authentic casts from the Turonian of Sarthe, and the *Craie chloritée* (Upper Greensand) of Rouen.

Length, 64 mm.; height, 37 mm.; thickness, 41 mm.

In form this species is very similar to, if not identical with, *A. Passyana* d'Orb., 1844 (Paléont. Franç., Terr. Crét., III, p. 241, Pl. cccxxvii, figs. 1, 2), of which, at the time of publication, d'Orbigny knew only the cast. Fraas (Aus dem Orient, I. Theil, p. 89) speaks of *A. brevifrons* Conrad (Official Report, p. 215. Pl. v, fig. 31) as closely resembling *A. Passyana;* but if Conrad's figures of Syrian species of Arca are at all to be relied on, *Passyana* and *Ligeriensis* approach nearest to *A. indurata* Conrad (op. cit., p. 216, Pl. v, fig. 33), and may be identical with it. Coll. Merrill.

Locality and Position. — Beirût district; from the Turonian.

Cucullæa (Trigonoarca) concinna Goldfuss sp.

Plate VI, figs. 7 a, b, c.

? *Cucullæa Munsterii* Zieten, 1830, Versteinerungen Würtembergs, p. 75, Pl. lvi, figs. 7 *a–c.*
Arca concinna Goldfuss, 1838, Petrefacta Germaniæ, II, p. 148, Pl. cxxiii, figs. 6 *a, b.*
Cucullæa concinna Quenstedt, 1852, Handbuch der Petrefactenkunde, p. 526, Pl. xliii, fig. 27.

Thirteen specimens, varying much in size, of which the largest is figured. Length, 8½ to 15 mm.; height, 6½ to 9 mm.; thickness, 4 to 7 mm.

These specimens agree perfectly with examples from the *Marnes oxfordiennes* of Salins, and with Goldfuss's description and figures. Numerous specimens from de Koninck's collection, now in the Museum of Comparative Zöology, and labelled by him "*Arca* (*Cucullæa*) *Munsterii* Zieten," from the *Lias moyen* of Balingen, as well as Zieten's figures of his own species, differ from specimens of *concinna* Goldf. from Lebanon and elsewhere, and from Goldfuss's and Quenstedt's figures of the same, only in lacking the anterior radial lines, which upon some examples of *concinna* are very obscure. *Cucullæa concinna* Phillips, 1829 (Geology of Yorkshire, Part I, p. 109, Pl. v, fig. 9), from the Oxford Clay of Scarborough (figured as 33 mm. long, and 15 mm. high), bears strong likeness to the smaller *concinna* Goldf. in form and markings. *Munsterii* Goldf., as figured in Petrefacta Germaniæ, is distinct from *Munsterii* Zieten.

Of eight lots in the Museum collections, from the Lias and Oxford Clay of Europe, and bearing the names given in the synonymy above, all are pyritiferous, as are our Lebanon specimens; and from the coincidence of the latter with the European specimens in their peculiar mineralization, condition of surface, and even color, all might be supposed to have come from one and the same deposit. All alike seem to have lost from the test a thin outer layer, portions of which are retained on a single specimen from Salins. Coll. Bird.

Locality and Position. — Unmistakably Jurassic, and probably from the Ornati Clay of Mejdel esh Shems.

Perna orientalis, sp. nov.

Plate VI, figs. 1 a, b, c.

Testa cuneato-subquadrata, subæquivalvis, altitudo longitudinem multo superans, antice crassa, postice coarctata et in alam brevem producta: margo cardinalis obliquus, rectiusculus; area cardinalis interna lata, canaliculis parallelis ligamentum multipartitum excipientibus circiter novem incavata; canaliculi spatiis interjectis latiores: umbones terminales, acuti, adunci, approximati: margo anticus insinuatus; sinus byssi latus, profundus, rugosus: superficies lateralis valvarum lamellis incrementi tenuissimis inducta: impressio muscularis subcentralis valde excavata.

Shell cuneately subquadrate, subequivalve, height greatly exceeding the length, anteriorly thick, behind compressed and produced into a short imperfect wing: hinge margin oblique, nearly straight; internal hinge area broad, grooved with about nine parallel furrows, constituting a series, which receive the many-parted ligament; the furrows wider than the intervening spaces: umbones terminal, sharp and hooked: anterior margin sinuated; byssal sinus broad, deep, rugose: sides of the valves overlaid with very thin lamellæ of growth: muscular impression nearly central and remarkably deep.

Two specimens: one nearly entire, the other a single left valve. Dimensions of entire shell: length, 32 mm.; height, 53 mm.; thickness, 32 mm. Dimensions of single valve: length, 35 mm.; height, 62 mm. (originally about 66 mm.); thickness, 23 mm.

This species is proportionally much thicker in front, and has a relatively wider and deeper byssal sinus than any hitherto described. As seen from the side, its outline somewhat resembles *P. mytiloides* Lam., which, however, in all specimens and figures known to me, is comparatively flat and thin, and

has the lateral surface of its valves covered with few and wide lamellæ; while those of our examples are numerous, narrow, and exceedingly thin, the anterior edges only of the valves being rugose. The test is exceptionally thick and massive, and in the single valve the muscular impression is a deep pit with an abrupt bounding wall on the front side.

Neither Conrad, Lartet, nor Fraas records any species of fossil *Perna* as occurring in Syria, nor did Coquand meet with the genus in Algeria, where the prevailing formation is Cretaceous. It is worthy of note, too, that Pictet and Campiche failed to detect Pernæ in the Cretaceous of Sainte Croix, Switzerland, that Meek found none in the Cretaceous and Tertiary of the Upper Missouri country, that Ferdinand Roemer found none in the Cretaceous of Texas, and that but a single species has been recognized in the Cretaceous of all India. On the other hand, d'Orbigny gives five species as belonging to the Cretaceous of France, and Reuss describes three from the Cretaceous of Bohemia. Species are numerous in the Jurassic. Coll. Bird.

Locality and Position. — If Jurassic, as they have the appearance of being, the fossils are probably from Mejdel esh Shems.

Perna tetragona, sp. nov.

Plate VI, fig. 2.

With the specimens described under the last title was a right valve, from the thin lower and posterior margins of which small portions have been broken away. This valve so closely resembles the others in its sharp and hooked beaks, in the narrow and delicate lamellæ upon the lateral surfaces, and in the width, depth, and rugosity of the byssal sinus, that, taking into account the wide range of variation which is observed in recent species of *Aviculidæ*, it is possible that this is only a variety of *orientalis*.

Yet the thin, flat, quadrangular form of the valve, the absence of any deep or distinctly limited muscular impression, the hinge margin nearly horizontal in direction, while that of the other specimens is abruptly sloping, and the ligamental grooves narrower than their interspaces, constitute distinctive characters so striking, that, if found to be constant in specimens hereafter to be discovered, they will require the establishing of a new species, to which we have given provisionally the name placed above. Coll. Bird.

Locality and Position. — Doubtless the same as for the last species.

Vola Syriaca Conrad sp.

Plate V., figs. 4 a-c.

Janira Syriaca Conrad, Official Report, p. 230, App., Pl. i, fig. 6.

A single specimen, in so much better condition than Conrad's type, that it is here figured anew. The specimen is almost absolutely perfect, except for the loss of the posterior ear, and of part of the other. It shows that what, in his excellent description, Conrad calls "wrinkles" upon the ribs, are more correctly thin erect scales of small height, and that upon the concave or left valve they run more or less obliquely across the ribs and the intervals between the ribs. On the convex or right valve the scales cross the ribs at right angles with their length, but are hardly perceptible in the interspaces. In each of the five spaces between the six larger ribs which characterize the right valve are four smaller ribs, of which the two middle ones exceed the outer in size. Coll. Bird.

Locality and Position. — Conrad's type was found at Abeih, whence this probably came. Related species are found in the zone of Ammonites Syriacus, and this may be from the same horizon.

Vola tricostata Coquand sp.

Janira tricostata Coquand (non Bayle), 1862, Géol. et Paléont. de Constantine, p. 219, Pl. xiii, figs. 3, 4.
" " Lartet, 1875, Expl. Géol. de la Mer Morte, p. 136, Pl. xi, fig. 16.

A lower (right) valve, incomplete, but showing well the characteristic features of the species; viz. six principal radiating ribs, the intervals of which contain each three unequal intermediate ribs, the median rib being always stronger than the other two. Coll. Thomson.

Locality and Position. — Beirût district. Fraas knew the species from Muktârah in the same district, and refers it to the zone of Ammonites Syriacus. Coquand assigns it, in Algeria, to *les assises rhotomagiennes.*

Vola Dutrugei Coquand sp.

Janira Dutrugei Coquand, 1862, Géol. et Paléont. de Constantine, p. 219, Pl. xiii, figs. 1, 2.
" " Lartet, 1875, Expl. Géol. de la Mer Morte, p. 137, Pl. xi, fig. 18.

An imperfect lower (right) valve, which exhibits fairly the proportions and arrangements of the ribs characteristic of the species. Coll. Thomson.

Locality and Position. — Beirût district. Not known to Fraas, but found by Lartet *assez répandue en Palestine*. Since Coquand refers it, in Algeria, to the same horizon (*l'étage rhotomagien*) with the last species, like that it is probably from the zone of Ammonites Syriacus, in Lebanon.

Vola sp.?

A single incomplete lower valve, less convex than the last two and proportionally wider. Length, about 45 mm.; height, about 50 mm. The ribs are about twenty in number, and are wide, except those of the anterior and posterior sides, which are narrower. All are very flat, and would entitle the species to the name of *Vola planicosta* if the specimen were complete enough to warrant a specific description. The upper (left) valve is unknown to us. Coll. Merrill.

Locality and Position. — Beirût district; from a chalky marl, probably Senonian.

Ostrea Syriaca? Conrad.

Ostrea Syriaca Conrad, Official Report, p. 212, Pl. ii, fig. 12.

Two complete specimens of a small Oyster, adhering to each other and giving evidence of having been attached at the umbones. They answer better to the description of this species than to that of any other. Greater diameter of the larger, 47 mm.; of the smaller, 45 mm. Coll. Thomson.

Locality and Position. — Probably from the Beirût district; from a yellow marl, Turonian.

Ostrea (Alectryonia) alicula, sp. nov.

Plate VI, figs. 3 a, b, c.

Testa oblique cuneiformis; valva superior fere plana, ad cardinem versus paulum convexa et concentrice tenuiter lamellosa, alioqui vix concava et plicis radiantibus latis demissis nonnunquam dichotomis notata; valva inferior alte fornicata, umbone producto affixa, costis angustis acutis crebris dichotomis munita.

Shell obliquely cuneiform; upper valve nearly flat, towards the hinge somewhat convex and concentrically delicately lamellose, for the rest slightly concave and having the lamellæ crossed by wide, low, radiating folds, sometimes dichotomous; lower valve highly arched, affixed by the elongated umbo, and furnished with narrow, sharp, close-set dichotomous ribs.

Two specimens, both figured. Dimensions of the right-hand individual of the doublet: length, 16 mm.; height, 40 mm.; thickness, 15 mm

This species might be mistaken for *O. virgata* Goldfuss, were it not that, in accordance with Goldfuss's description and figures, all specimens of that species which have come under my observation have the upper valve flat and concentrically wrinkled, without the radiating folds and slight concavity which are seen in the Lebanon specimens. *O. virgata*, moreover, is on record as strictly a Tertiary species, while the fossils before us clearly antedate the Tertiary period.

I suspect this to be what Fraas has figured from part of a lower valve (Aus dem Orient, II. Theil, p. 46, Pl. ii, fig. 3) as *O. succini* Fraas, concerning which the explanatory text accompanying the figure is only the following: "*Ostrea succini* is so characteristic in the whole of southerly Lebanon as an associate of the Amber, that we name the Oyster from the accompanying mineral. It is a small ribbed Oyster which is nearly like the Jurassic *O. subserrata* or *costata*, and is always swollen with a broader basis. The specimen figured is one of the largest, which we found in the neighborhood of Djebâa. Usually there is a whole colony of such Oysters together, and grown to one another." Fraas names this as one of four species characteristic of the Cenomanian Sandstone, the second of the nine members into which he divides the Cretaceous strata of Lebanon.

Of at least two different Oysters which Conrad with some hesitation describes and figures under the name *O. virgata* (Official Report, pp. 212 and 230, Pl. i, figs. 6–8, and App., Pl. i, fig. 8), from the Cretaceous district of Bhamdûn, one is perhaps the species here considered, though an upper valve supposed to belong to it is drawn without radiating folds.

Since Fraas's figure of the fragment of a single valve, without an adequate description accompanying it, gives no certainty in the case, I find myself obliged to present the species under a new name, though loth to add to the maze of fossil Oysters. Coll. Bird.

Locality and Position. — Beirût district; from an arenaceous bed which is probably the Cenomanian Sandstone.

Ostrea (Exogyra) flabellata? Goldfuss.

Exogyra flabellata, Goldfuss, 1834, Petrefacta Germaniæ, II, p. 38, Pl. lxxxvii, figs. 6 *a*, *b*.
Ostrea flabellata, D'Orbigny, 1842, Paléont. Franç., Terr. Crét., III, p. 717, Pl. cccclxxv.

Two well preserved lower valves; one complete and having greater diameter 101 mm.

These specimens coincide with d'Orbigny's figures of *O. Boussingaultii* d'Orb. (Paléont. Franç., Terr. Crét., III, p. 702, Pl. cccclxviii), and with Conrad's figures of two very imperfect valves to which he gives the same name (Official Report, p. 213, Pl. ii, figs. 10, 11). But that species was regarded by d'Orbigny as "propre aux couches inférieures de l'étage néocomien" (loc. cit.), of the existence of which formation in the Lebanon region there is at present no evidence. D'Orbigny says also of the species as compared with *flabellata:* "Les rapports sont si intimes que je n'aurais pas balancé à réunir ces deux espèces, si elles avaient appartenu à la même couche; mais l'*O. Boussingaultii* se trouvant dans l'étage néocomien, elle est séparée de l'*O. flabellata* par les étages aptien et albien qui ne la renferment pas; aussi est-il impossible d'en suivre la filiation." (loc. cit.)

Lartet affirms (Expl. Géol. de la Mer Morte, p. 138) that the Oysters from Kerak, east of the Dead Sea, identified by Conrad and Fraas (Aus dem Orient, I. Theil, p. 86) as *O. Boussingaultii*, are in reality *O. flabellata.* In the second part of the same work, p. 79, Fraas, influenced perhaps by Lartet's opinion, for which he always manifests great respect, assigns to the species *flabellata* the related Oysters found in Lebanon.

Out of deference to these views, I have named my specimens as above, with some doubt, which is not diminished by the fact that Zittel assigns *O. Boussingaultii* to the subgenus *Amphidonta*, and *O. flabellata* to the subgenus *Exogyra!* Coll. Merrill.

Locality and Position. — From the Beirût district. Fraas refers *O. flabellata* to the zone of Ammonites Syriacus, or the Middle Turonian.

UNDETERMINED.

The cast from the Merrill collection, represented in Plate IV by figures 4 *a*, *b*, is certainly not a *Lucina.* In the projection upon the posterior (?) part of each valve (largest on the right), fig. 4 *b*, it approaches *Arcopagia*, for example the species *remies* Linn.; but I am not prepared to refer it to that group.

BRACHIOPODA.

Terebratula biplicata Brocchi sp.

Anomia biplicata Brocchi, 1814, Conchiologia Fossile Subapennina, p. 469, Pl. x, fig. 8.
Terebratula biplicata Sowerby, 1815, Min. Conch. Gr. Brit., I, p. 201, Pl. xc, and V, p. 53, Pl. ccccxxxvii, figs. 2, 3, 1825.
" " D'Orbigny, 1847, Paléont. Franç., Terr. Crét., IV, p. 95, Pl. dxi, figs. 9–15.
" " Davidson, 1852–55, Monogr. Brit. Foss. Brach., I, Pt. ii, p. 55, Pl. vi, figs. 1–49.

Three specimens, complete, of the form represented by Davidson's figures 8 and 9. Coll. Bird.

Locality and Position. — Vicinity of Abeih; referred by Fraas to the Glandarius zone of the Cenomanian, the lowest of his nine zones of Lebanon strata. D'Orbigny speaks of the species as "caractéristique des couches les plus inférieures de l'étage cénomanien." (loc. cit.) Davidson states that in England it is found in the Gault, Upper Greensand, and Lower Chalk; upon the Continent, in the Gault and Upper Greensand.

Rhynchonella concinna Sowerby sp.

Terebratula concinna Sowerby, 1815, Min. Conch. Gr. Brit., I, p. 192, Pl. lxxxiii, fig. 6.
" " Von Buch, 1838, Class. et Descr. des Térébrat, Mém. Soc. Géol. France, III, p. 144, Pl. xiv, fig. 14.
Rhynchonella concinna D'Orbigny, 1847, Prodrome, I, p. 315.
" " Davidson, 1851–52, Monogr. Brit. Foss. Brach., I, Pt. III, p. 88, Pl. xvii, figs. 6–12.

Five specimens, in the best condition and of typical form, admirably figured by von Buch. Four adult, one younger. Coll. Bird.

Locality and Position. — Fraas recognized this well-known European species in the Older Brown Jura bed of Mejdel esh Shems, whence these specimens were probably obtained. D'Orbigny refers the species to his Bathonian stage. Davidson mentions it as "abundant in the Great Oölite of many localities in England." (loc. cit.)

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PLATE I.

[All figures on this Plate are of natural size.]

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Front view.

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2 *b*. Dorsal view.

Fig. 3. **Amauropsis gradata** 16
Front view.

Fig. 4. **Tylostoma Birdanum** 18
Front view.

Fig. 5. **Amauropsis subcanaliculata** 15
Front view.

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Fig. 7. **? Tylostoma depressum** PICTET and CAMPICHE 21
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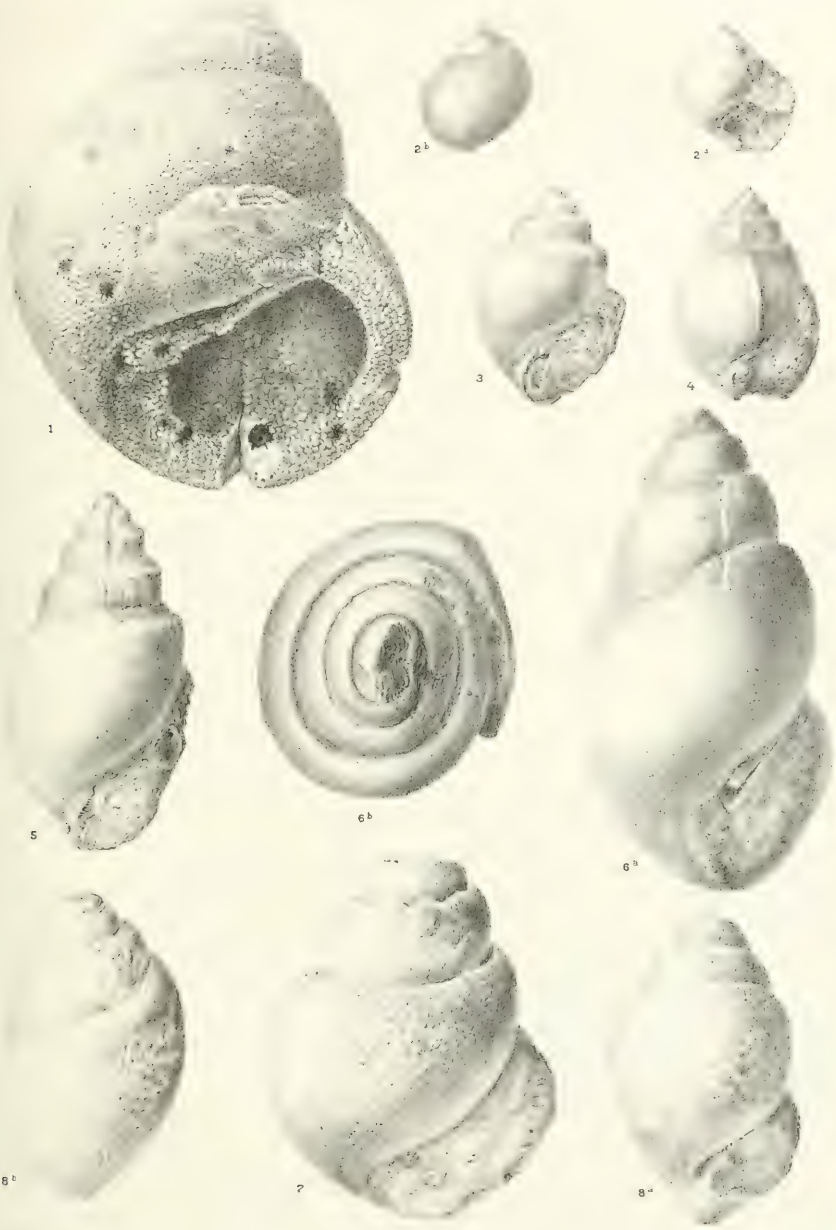
8 *a*. Left side view, oblique, showing aperture and perforated columella.
8 *b*. Right side view. A full dorsal view, which it was intended to give, would show better the produced anterior.


1
2b
2a
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6b
6a
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8a

PLATE II.

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Fig. 1. **Turritella elæonis** 22
1 *a*. Dorsal view of imperfect specimen, with test. Enlarged two diameters.
1 *b*. Single whorl of cast. Enlarged to show revolving lines.

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Fig. 3. **Scalaria** sp. ? 23
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6 *a*. Front view of best preserved specimen.
6 *b*. Dorsal view of second specimen, showing single digitation.
6 *c*. Dorsal view of third specimen, showing best the canal.
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Fig. 8. **Nerinea (Cryptoplocus) Libanensis** 26
8 *a*. Dorsal view of an imperfect specimen.
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Fig. 10. **Tylostoma Syriacum** CONRAD sp. 19
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1a
1b
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2a
3b
3a
4
6a
6c
6b
5a
5b
9a
9b
7
8a
8b
10

PLATE III.

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Fig. 1. **Actæonina vafra** 29

1 *a*. Front view.

1 *b*. Left side view, showing umbilical chink.

A full dorsal view would better show the sudden anterior contraction of the body-whorl.

Fig. 2. **Actæonina brevis** MORRIS and LYCETT 32

2 *a*. Front view of the original type specimen. Natural size.

2 *b*. Front view of the same specimen. } Enlarged two diameters.

2 *c*. Top (posterior) view of the same. }

Fig. 3. **Colostracon sinuatum** 33

3 *a*. Front view. Natural size.

3 *b*. Front view of same specimen. } Enlarged two diameters.

3 *c*. Top (posterior) view of same. }

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4 *a*. Front view. Natural size.

4 *b*. Front view of same specimen. }

4 *c*. Dorsal view of same. } Enlarged two diameters.

4 *d*. Top (posterior) view of same. }

Fig. 5. **Colostracon Lewisii** FRAAS 35

Fraas's figures reproduced.

5 *a*. Front view of type specimen. } About the natural size.

5 *b*. Top (posterior) view of same. }

Fig. 6. **Melo pervetus** CONRAD sp. 35

Dorsal view of cast, nearly entire. Natural size.

Fig. 7. **Cardium (Acanthocardia) Syriacum** CONRAD sp. 48

7 *a*. Left side view of cast. }

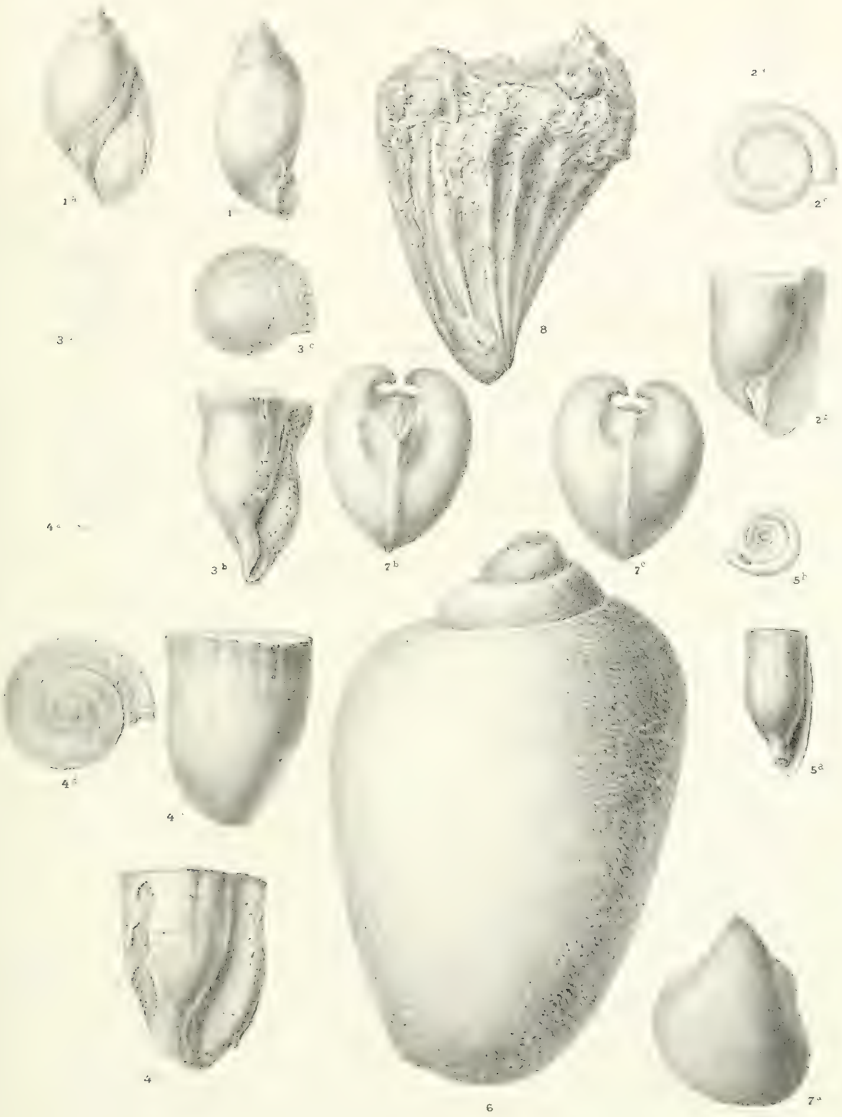
7 *b*. Posterior view of same. } Natural size.

7 *c*. Anterior view of same. }

Fig. 8. **Hippurites Lewisii** FRAAS 54

View of flatter side of a well-preserved lower valve. Natural size.

NOTE. — The wood-cut of *Cerithium gracilens*, p. 36, represents, in natural size, an imperfect specimen, partially restored by means of smaller specimens which retain features obscured in the original of the figure. The row of indistinct tubercles on the base of the last whorl was overlooked by the artist.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2 c
3 a
3 c
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3 b
7 b
7 c
4 c
5 b
4 b
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5 a
6
4
7 a

PLATE IV.

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Fig. 1. **Gonodon? hebes** 52

1 *a*. Right side view.
1 *b*. Anterior view of same. } Natural size.
1 *c*. Dorsal view of same.
1 *d*. Remaining teeth, looking from above. Enlarged.

Fig. 2. **Cyprina (Venilicardia?) Abeihensis** 45

2 *a*. Left side view.
2 *b*. Anterior view of same. } Natural size.
2 *c*. Posterior view of same.

Fig. 3. **Cytherea (Callista?) Libanotica** 42

3 *a*. Left side view of largest of several casts.
3 *b*. Dorsal view of same specimen. } Natural size.
3 *c*. Left side view of smallest cast.

Fig. 4. An undetermined cast 64

4 *a*. Side view of single specimen. } Natural size.
4 *b*. Dorsal view of same.

Fig. 5. **Cardium (Protocordia) Judaïcum** 50

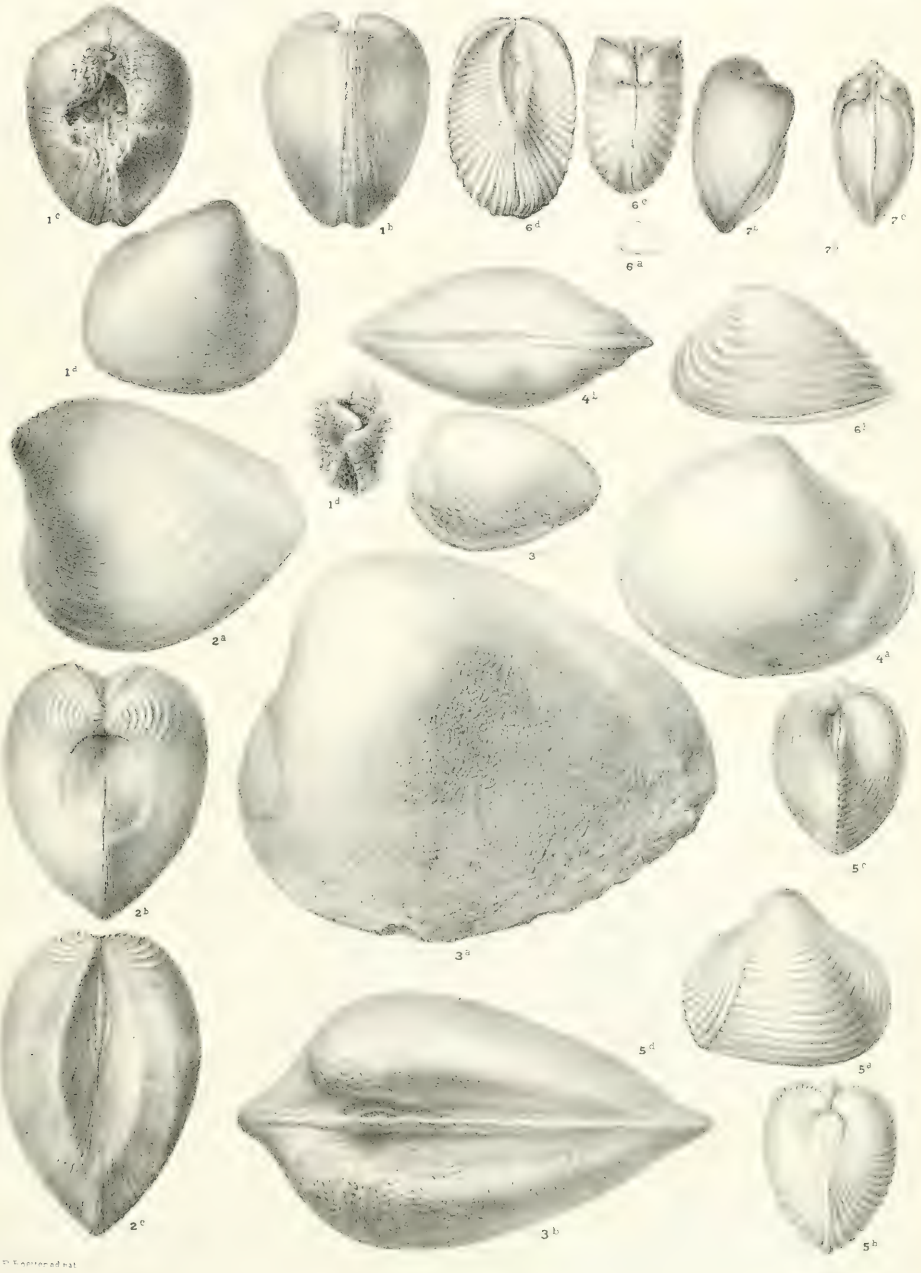
5 *a*. Right side view of larger of two specimens.
5 *b*. Anterior view of smaller " " } Enlarged one and a half diameters.
5 *c*. Posterior view of smaller.
5 *d*. Anterior view of smaller, in outline. Natural size.

Fig. 6. **Corbula aligera** 38

6 *a*. Left side view, in outline. Natural size.
6 *b*. Left side view of same specimen.
6 *c*. Anterior view of same. } Enlarged four diameters.
6 *d*. Posterior view of larger specimen.

Fig. 7. **Cucullæa (Trigonoarca) concinna** GOLDFUSS 58

7 *a*. Left side view of largest of many specimens, in outline. Natural size.
7 *b*. Left side view of same specimen. } Enlarged two diameters.
7 *c*. Posterior view of same specimen.


1c
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6b
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3
2a
4a
5c
2b
3a
5d
5e
3b
2c
5b

PLATE V.

PAGE

Fig. 1. **Cardita lacunar** 53

1 *a*. Left side view. Natural size.

1 *b*. Same, showing *lacunaria* between posterior ribs. } Enlarged three and a

1 *c*. Right side view of a larger shell. } half diameters.

1 *d*. Dorsal view of shell represented by Figs. 1 *a*, *b*. Natural size.

1 *e*. Same. Enlarged four diameters.

Fig. 2. **Isocardia Merrilli** 43

2 *a*. Left side view of cast. Badly placed through misunderstanding of artist. } Natural size.

2 *b*. Anterior view of same. } Natural size.

2 *c*. Anterior view of another cast, better showing pallial line, pits, and muscular scars. } Natural size.

Fig. 3. **Cyprina orientalis** 44

3 *a*. Left side view of the only cast. } Natural size.

3 *b*. Anterior view of the same. } Natural size.

Fig. 4. **Vola Syriaca** CONRAD sp. 61

4 *a*. Outer view of lower (right) valve. Natural size.

4 *b*. Same. Enlarged about one diameter and a half.

4 *c*. Outer view of upper (left) valve. Enlarged about one diameter and a half.

1a
1b
1c
1
1d
4c
2c
2a
4b
4a
2b
3b
3a

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1a
1b
3c
3b
3a
4a
5b
5a
5c
1c
2
5d
5e
5f
4b
4c
5g
6b
5h
6c
6a
7a
7b
8b
7c

Memoirs of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
Vol. X. No. 4.

A

REVISION OF THE ASTACIDÆ.

By WALTER FAXON.

Part I. THE GENERA CAMBARUS AND ASTACUS.

WITH TEN PLATES.

CAMBRIDGE:
Printed for the Museum.
August, 1885.

PREFACE.

The following Revision of the crayfishes of the Northern hemisphere is based mainly upon the material in the Museum of Comparative Zoölogy. Through gifts from friends, and through a system of exchanges carried on during the past few years, the Museum now possesses all the known species of Astacus from Europe and Asia, together with all the American species of Astacus and Cambarus excepting *Cambarus angustatus* (Le Conte), *C. Wiegmanni* Erichs., and *C. Mexicanus* Erichs., and the doubtful species *C. maniculatus* (Le Conte), *C. Stygius* Bundy, *C. Nebrascensis* Girard, and *Astacus Oreganus* Randall. In this collection is included the chief part of the material used by Dr. Hagen in the preparation of his Monograph of the North American Astacidæ, a work which forms the foundation of our knowledge of the crayfishes of this continent. One may form some notion of the importance of the material received since the publication of Hagen's memoir, from the fact that twenty new species of Cambarus are made known in the following pages,* while Dr. Hagen described but ten unknown to previous authors.

Besides the collection in the Museum of Comparative Zoölogy, I have examined these:—

1. The collection in the United States National Museum at Washington. Next to that at Cambridge this is the richest collection of Astacidæ in the United States, and both have been much benefited by interchanges. All of the new material received at the National Museum during the preparation of this Revision has been promptly sent to me for study. For this invaluable aid I am under great obligation to Prof. S. F. Baird, Director of

* Since this was written, descriptions of the new species have been printed in the Proceedings of the American Academy of Arts and Sciences, Vol. XX. pp. 108–135, December, 1884. Such a course seemed desirable on account of delay in the publication of the complete memoir.

the National Museum, and to Mr. Richard Rathbun, Curator of Invertebrata. Of the types of Girard's and Stimpson's species which this collection once contained, I was able to find only two, *C. Pealei* Gir. (= *C. affinis* Say) and *A. Trowbridgii* Stm. The rest were probably lost in the great fire of Chicago in 1871, while in Stimpson's hands.

2. Through the courtesy of the Council of the Academy of Natural Sciences of Philadelphia, I have had the opportunity to inspect the Astacidæ in the collection belonging to the Academy; and the specimens that demanded more than a cursory examination have been sent to me in Cambridge. This collection, although small, is of great historical interest, since it contains many apparently authoritative examples of Girard's species, together with types of species described by Harlan, Gibbes, and Le Conte. It was examined by Hagen also in the course of the preparation of his Monograph.

3. The collection of the Peabody Museum of Yale College, New Haven, Conn., containing types of *Astacus Trowbridgii* Stimpson and *Cambarus Sloanii* Bundy.

4. The Astacidæ belonging to the Boston Society of Natural History.

5. The collection of the Peabody Academy of Science, Salem, Mass.

6. The valuable collection of Maryland and Virginia Cambari brought together by Mr. P. R. Uhler, of Baltimore, Maryland. This collection is contained in upward of one hundred and eighty jars. Through the labors of Mr. Uhler, Maryland is now one of the best explored States in the Union.

7. Prof. O. P. Hay of Butler University, Irvington, Indiana, has kindly offered for my examination an interesting collection of sixteen species of Cambarus secured in the West and South by himself and Prof. D. S. Jordan.

I take this opportunity also to acknowledge the loan of specimens from the private collections of Professors L. A. Lee, R. R. Wright, A. S. Packard, D. S. Jordan, and B. F. Koons, Dr. C. H. Merriam, and Messrs. R. S. Tarr and C. H. Gilbert.

The second part of this Revision will include the crayfishes of the Southern hemisphere, the Parastacinæ.

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A

REVISION OF THE ASTACIDÆ.

The family Astacidæ, in a strict sense, is equivalent to the genus Astacus, as limited by Milne Edwards in 1837.* Thus restricted, it includes only fresh-water species, the crayfishes proper, — animals closely related to the marine family of lobsters, or Homaridæ (Homarus, Nephrops, Nephropsis, Enoplometopus, Phoberus), from which they are distinguished by having the last segment of the thorax movably articulated with the preceding segment, and by having the podobranchiæ (or gills borne on the thoracic limbs) closely united to the epipodites (or external branches of the limbs), to the more or less complete suppression of the lamellar portion of the epipodite. On the other hand, the Astacidæ lead, through such forms as Thaumastocheles† and Calocaris, to the fossorial Thalassinidæ.

Thus limited, the Astacidæ are Macrourous Decapod Crustacea, with carapace produced into a rostrum in front, and divided by a transverse groove (cervical groove); narrow thoracic sterna; posterior thoracic somite united to the preceding somite by a movable joint; second to sixth abdominal somites with a broad descending lateral plate (pleuron) on each side, which protects the abdominal appendages; antennules terminated by two filaments; antennæ furnished with a movable external scale or squame;‡ first pair of legs much enlarged, chelate; second and third pairs of legs with small chelæ; last two pairs of legs not chelate; first pair of abdominal

* Histoire Naturelle des Crustacés, Tom. II. p. 329.

† A genus founded by Wood-Mason (Proc. Asiatic Soc. Bengal, 1874, p. 181) for the reception of *Astacus zaleucus* Willemoes-Suhm, brought up by the "Challenger" from a depth of 450 fathoms, near Sombrero Island, West Indies. See Trans. Linn. Soc. London, 2d Series, Vol. I., Zoöl., pp. 48–50, Pl. X. fig. 1. Until the structure of the gills is known, it is impossible to say whether, from the sum of its characters, Thaumastocheles should be placed among the Astacidæ or among the Thalassinidæ.

‡ The antennal scale is very small in *Astacoides Madagascariensis* Aud. et M. Edw.

appendages of male transformed into styliform organs, or else absent; external branch of posterior pair of appendages divided by a transverse suture; gills composed of a stem beset with numerous cylindrical filaments (trichobranchiæ), those borne on the proximal segments of the thoracic appendages (podobranchiæ) imperfectly, or not at all, separated into a proper branchial and a lamellar portion; just in front of the base of the podobranchiæ a pencil of long, fine setæ (coxopoditic setæ) arises from a small papilla on the proximal segment of the legs.

Huxley has shown, in his essay "On the Classification and the Distribution of the Crayfishes,"* that the family Astacidæ, as defined above, naturally falls into two subordinate groups, to which I would assign the value of subfamilies, viz.: —

1. The POTAMOBIINÆ, comprising the crayfishes of North America, Europe, and Asia. In these the first abdominal somite in the male bears a pair of styliform appendages;† the podobranchiæ borne on the second and third maxillipeds and on the first three pairs of legs are furnished with a broad bilobed plaited lamina; the epipodite of the first maxilliped is destitute of branchial filaments; the coxopoditic setæ are acute, not hooked, at the end; the telson is commonly divided more or less completely by a transverse suture.

The subfamily Potamobiinæ includes two genera: —

a. Cambarus, distinguished principally by the absence of gills on the last thoracic somite and the absence of a bilobed lamina from the podobranchiæ of the penultimate pair of legs. (Page 3.)

b. Astacus, characterized chiefly by the presence of a pair of branchiæ on the wall of the last thoracic somite, and a folded lamina on the podobranchiæ of the thoracic appendages from the second maxilliped to the penultimate pair of legs inclusive. (Page 125.)

2. The PARASTACINÆ, comprising all the crayfishes of the Southern hemisphere; viz. those of South America, Madagascar, Australia, Tasmania, New Zealand, and the Feejee Islands.‡ In this subfamily the first abdominal somite is devoid of appendages in both sexes; the podobranchiæ

* Proc. Zoölog. Soc. London, 1878, pp. 752–788.

† The first abdominal appendages are rudimentary or absent in the female.

‡ In the collection of the United States National Museum there is a specimen of an undescribed Parastacine from Colima, Mexico, collected by J. Xantus. This is the only representative of the Parastacinæ which has been found north of the equator. According to Huxley, *op. cit.*, p. 771, there are two specimens of Paranephrops from the Feejee Islands in the British Museum. Perhaps the locality labels of the Mexican and Feejee specimens are erroneous.

lack the bilobed plaited lamina of the Potamobiinæ, although the stem may be expanded into a wing; the epipodite of the first maxilliped almost always carries branchial filaments; the coxopoditic setæ terminate in hooks; the telson is not divided by a transverse suture.*

Six genera of Parastacinæ have been described; viz. *Astacoides*, by Guérin; *Cheraps* and *Engæus*, by Erichson; *Paranephrops*, by White; *Astacopsis* and *Parastacus*, by Huxley. Some of these genera are based on too trivial characters to be valid. The group will be revised in the second part of this memoir.

CAMBARUS.

In the genus Cambarus, established by Erichson in 1846,† the cephalothorax is subcylindrical. The last thoracic somite is devoid of gills, neither are there any traces of rudimentary pleurobranchiæ on the anterior somites; the hindmost podobranchia has no lamina. The branchial formula is as follows: —

Somite.‡	Podobranchiæ.	Arthrobranchiæ. Anterior.	Arthrobranchiæ. Posterior.	Pleurobranchiæ.		
VI.	0 (ep.)	0	0	0	=	0 (ep.)
VII.	1	1	0	0	=	2
VIII.	1	1	1	0	=	3
IX.	1	1	1	0	=	3
X.	1	1	1	0	=	3
XI.	1	1	1	0	=	3
XII.	1	1	1	0	=	3
XIII.	0	0	0	0	=	0
	6 + ep.	+ 6	+ 5	+ 0	=	17 + ep.

This gives a total of thirty-four branchiæ, counting those on both sides of the thorax. The orifice of the green gland is situate near the apex of the

* Chilton (Trans. New Zealand Inst., Vol. XV. pp. 152, 163, Pl. xx. fig. 7, 1882) has observed that the internal male reproductive organs in *Paranephrops setosus* are very different from those in the Potamobiinæ. In the former the testes are two long tubes united by a transverse commissure, while in the latter they form a trilobed organ through the coalescence of the right and left testes posterior to the vasa deferentia. I have dissected an undescribed Parastacine from Chili, and find the testes to agree with those of Paranephrops. It will probably be found that all the Parastacinæ agree in this regard. On account of the resemblance of the internal male generative organs in Paranephrops and Palinurus, and the further agreement of the Parastacinæ and Palinuridæ in the absence of the first pair of abdominal appendages and presence of hooked setæ, Chilton has forced these groups into too close relationship. Cf. T. Jeffery Parker, in the same journal, Vol. XVI. p. 305.

† Uebersicht der Arten der Gattung Astacus. Arch. f. Naturgesch., XII. Jahrg., Bd. I. p. 88.

‡ The somite that bears the first pair of maxillipeds is here reckoned as the sixth.

short conical tubercle of the basal segment of the antennule. The third (in *C. Montezumæ* and *C. Shufeldtii* the second and third), or the third and fourth pairs of legs in the male, have a prominent tubercle or hook on the anterior border of the third segment. The first pair of abdominal appendages in the male are terminated by styles, hooks, or teeth.* A more or less mobile annulus is situated on the sternum of the female, just behind the penultimate thoracic somite;† and in this sex the first pair of abdominal appendages, though much smaller than the succeeding pairs, and simple, are somewhat larger than in the genus Astacus. The telson is clearly divided by a transverse suture.

The genus Cambarus is widely distributed over the North American continent, from Lake Winnipeg to Guatemala, from New Brunswick to Wyoming Territory. For a fuller account of the geographical distribution of the genus, the reader is referred to page 178.

Bibliography of the Genus Cambarus, from the Year 1868 to the Present Time.

Although seventeen years have elapsed since the genus Cambarus was revised by Dr. Hagen,‡ but little has been added to our knowledge of these animals during that period. The bibliography of the genus down to the year 1868 has been given with sufficient fulness on pages 5–12 of Hagen's memoir. I will briefly mention the works published since that date which treat of these animals.

1871. E. D. Cope, in an article entitled "Life in the Wyandotte Cave," in the Indianapolis Journal, Sept. 5 (reprinted in Ann. and Mag. of Nat. Hist., 4th Ser., Vol. VIII. pp. 368–370), records the capture of a blind crayfish in the Wyandotte Cave, Crawford Co., Ind. It is considered to be the same as the Mammoth Cave species, *C. pellucidus*.

1872. In a "Report on the Wyandotte Cave and its Fauna" (Third and Fourth Ann. Rep. Geolog. Surv. Ind., pp. 157–182; Amer. Nat., Vol. VI. pp. 406–422), Cope gives a fuller account, accompanied by a figure, of the Wyandotte Cave species, which, after comparison with *C. pellucidus*, he concludes to be a new species. This he names *Orconectes inermis*, establishing a new genus for the reception of the two blind species.

* A detailed description of these appendages will be found on page 17 of Hagen's Monograph of the North American Astacidæ.

† See Hagen, *op. cit.*, p. 19.

‡ Monograph of the North American Astacidæ, by Dr. Hermann A. Hagen. Ill. Cat. Mus. Comp. Zoöl., No. III. (Mem., Vol. II. No. 1), 1870. This monograph was finished in 1868, although not published till two years later.

In the next number of the American Naturalist, Aug., 1872 (Vol. VI. p. 494), Hagen doubts the specific difference of the two cave forms, and opposes the establishment of a new genus based on the rudimentary condition of the eyes.

1872. In a memoir "Ueber Cubanische Crustaceen" (Arch. f. Naturgesch., XXXVIII. Jahrg., Bd. I. pp. 77–147), E. v. Martens describes *Cambarus Cubensis* Erichs. from Cuba, and *Cambarus Montezumæ*, var. nov. *tridens*, from Mexico. Short diagnoses of *C. Cubensis* Erichs., *C. Wiegmanni* Erichs., *C. Mexicanus* Erichs., *C. Aztecus* Sauss., and *C. Montezumæ* Sauss., are added. Concerning the identity of *C. Cubensis* Sauss. and *C. consobrinus* Sauss., Von Martens is doubtful; but he thinks it probable, from specimens sent to the Berlin Museum by Dr. Gundlach, that there is a second Cuban Cambarus agreeing with *C. Cubensis* in the shape of the rostrum, but differing from it in the sexual appendages.

1873. In a paper "On the Cave Fauna of Indiana" (Fifth Ann. Rep. Peabody Acad. Sci., Salem, pp. 93–97), A. S. Packard, Jr. communicates the results of a comparison of the blind Cambari from the Mammoth and Wyandotte Caves. He concludes that they are one and the same species, and doubts, with Hagen, the validity of a genus based on the atrophy of the visual organs.

1873. Dr. Charles C. Abbott prints, in the American Naturalist, Vol. VII. pp. 80–84, "Notes on the Habits of certain Crawfish." The observations were made at Trenton, N. J., upon three species, — "*C. acutus* Gir." (*C. Blandingii*), *C. affinis*, and *C. Bartonii*. Specimens of all three of these species, received from Dr. Abbott, are in the Museum of the Peabody Academy of Science, Salem, Mass.

1874. Prof. S. I. Smith, in a paper on the Crustacea of the Fresh Waters of the United States, in U. S. Fish Commissioner's Report for 1872 and 1873, gives a list of the Astacidæ of the Northern United States east of the Mississippi River (pp. 637–639). This list is compiled from Hagen's Monograph, but adds new localities for *C. propinquus* and *C. Bartonii*. *Orconectes inermis* Cope is considered a synonym of *Cambarus pellucidus*.

1874. In "Remarks on the Mammoth Cave and some of its Animals" (Bull. Essex Inst., Vol. VI. pp. 191–200), Mr. F. W. Putnam speaks of the association of *C. pellucidus* and *C. Bartonii* in the Mammoth Cave of Kentucky. The occurrence of *C. pellucidus* near the entrance of another cave several miles from Mammoth Cave is noted, and observations are added on the color of cave specimens of *C. pellucidus* and *C. Bartonii*.

1875. Substantially the same observations are again printed by Mr. Putnam in Proc. Boston Soc. Nat. Hist., Vol. XVII. pp. 222–225.

1875. "On some of the Habits of the Blind Crawfish, *Cambarus pellucidus*, and the Reproduction of lost Parts." By F. W. Putnam. Proc. Boston Soc. Nat. Hist., Vol. XVIII. pp. 16–19. In this communication Mr. Putnam treats of the habits, coloration, exuviation, and restoration of lost parts in *C. pellucidus* and *C. Bartonii*. The observations were made upon living specimens, brought to Cambridge, Mass., from the Mammoth Cave. The specimens are now preserved in the Museum of Comparative Zoölogy. One of the specimens of *C. pellucidus* lived upwards of nine months in confinement, exposed to the full glare of day.

1875. In an essay "On the Antiquity of the Caverns and Cavern Life of the Ohio Valley" (Mem. Boston Soc. Nat. Hist., Vol. II. p. 362; also in Mem. Ky. Geolog. Surv., Vol. I. Part I., 1876), Professor N. S. Shaler speculates on the origin of the blind *Cambarus pellucidus* of the Mammoth Cave. (See p. 41.)

1875. Brocchi, in his "Recherches sur les Organes Génitaux Males des Crustacés Décapodes" (Ann. Sci. Nat., 6e Série, Zool. et Paléontol., Tom. II. Art. 2), figures the first

abdominal appendage of the male *Cambarus robustus* (Pl. XIII. fig. 15), and criticises Hagen for retaining the genus Cambarus as distinct from Astacus, and for dividing the genus into upwards of thirty species, based chiefly on the form of the male appendages. With regard to the first point, the generic value of Cambarus, Brocchi asserts that, of all the characters urged by Hagen as a warrant for the establishment of the genus, only one seems to him to be of any importance, namely, the absence of the posterior branchiæ, and this *he has not been able to verify!* He goes on to say (p. 26): "Si l'on prend, par exemple, le caractère tiré de la présence d'un ongle à la troisième et quatrième paire de pattes, je ferai observer qu'une seule espèce Cambarus, le *Cambarus acutus*, présente cet appendice à la troisième et quatrième paire de pattes; tous les autres ont seulement les quatrième et cinquième paires unguiculées, caractère qui leur est commun avec les Écrevisses [Astacus]." This passage is inexplicable to me, but seems to show a complete misconception of what Hagen means by the hooked legs of Cambarus. With regard to the second point, — Hagen's division of Cambarus into species, most of which, according to Brocchi, should be considered as simple varieties, — it must be admitted that there will always be a difference of opinion concerning the amount of variation necessary to warrant the erection of species; but I think that any zoölogist, with ample material before him, will admit the justice of Hagen's principle of division. Brocchi's censure of Hagen's work is wholly unmerited, and springs from ignorance of the subject under discussion. That the author does not understand the phenomenon of two forms of the male Cambari is shown on page 28. The final objection to Hagen's principle of classification, that it would lead to the breaking up of the European *Astacus fluviatilis* of authors into several species, is of no weight, since the dismemberment of that species was brought about long ago on other grounds than the character of the male appendages. Brocchi's *Astacus fluviatilis*, from Vaucluse (Pl. XII. figs. 12, 13), is *A. pallipes* Lereboullet.

1876. S. A. Forbes, in his "List of Illinois Crustacea, with Descriptions of New Species" (Bull. Ill. Mus. Nat. Hist., No. I. pp. 3–25), records, with annotations, *C. acutus* Gir., *C. virilis* Hag., *C. propinquus* Gir., *C. immunis* Hag., *C. obesus* Hag.; also, on the authority of Dr. Hagen, *C. troglodytes* and *C. placidus*. The second form of the male *C. immunis* Hag. is described for the first time. Three new species, described by W. F. Bundy, are included in the list: *C. Stygius*, from Lake Michigan; *C. Wisconsinensis*, from Normal, Ill., and Racine, Wis.; and *C. gracilis* from Illinois and Wisconsin. In an appendix to the list, Mr. Bundy describes two more new species of Cambarus from without the limits of the State of Illinois; viz. *C. Sloanii* from Southern Indiana and Kentucky, and *C. debilis* from Wisconsin.

Of Bundy's species I have seen types (in the Museum of Comparative Zoölogy) of *C. Wisconsinensis*, *C. gracilis*, *C. Sloanii*, and *C. debilis*. *C. gracilis* and *C. Sloanii* are good species. *C. Wisconsinensis* appears to be the same species as Hagen's *C. placidus* (= *C. rusticus*, var. ?). *C. debilis* is the second form of the male of *C. virilis* Hag. *C. Stygius*, according to Bundy in a later paper, closely resembles *C. acutus*, but differs in the shorter chelæ, which resemble those of *C. propinquus*. All of the specimens of this species seen by Bundy were mutilated, the fourth pair of legs being lost.

1877. Mr. Bundy ("On the Cambari of Northern Indiana," in Proc. Acad. Nat. Sci. Phila., 1877, pp. 171–174) records *C. immunis* Hag., *C. obesus* Hag., *C. virilis* Hag., and *C. propinquus* Gir., from Northern Indiana; redescribes *C. Sloanii* from Southern Indiana and Kentucky; and describes a new species, *C. spinosus*, from near Rome, Georgia. Through the courtesy of Mr. P. R. Uhler, the Museum of Comparative

Zoölogy has obtained types of *C. spinosus*. It is a distinct species from any previously described.

1877. Dr. Thomas H. Streets, in an article entitled "Description of *Cambarus Coucsi*, a new species of Crawfish from Dakota," in Bull. U. S. Geolog. and Geograph. Surv. Terr., Vol. III. pp. 803, 804, describes *C. Coucsi*, sp. nov., from the Red River of the North, and gives a note (by Dr. Coues) on the color of living *C. virilis*. Types of *C. Coucsi* have been received by the Museum of Comparative Zoölogy in exchange with the U. S. National Museum. They are not specifically distinct from *C. virilis*, agreeing fully with some of Hagen's types of that species.

1878. Huxley, in his essay "On the Classification and the Distribution of the Crayfishes," Proc. Zoölog. Soc. London, 1878, pp. 752–788, gives an account of the branchiæ in a species of Cambarus obtained near Coban, Vera Paz, Guatemala, at an elevation of about 4,300 feet above the sea. In his subsequent work, "The Crayfish," 1880, Professor Huxley gives a figure of the penultimate leg of this Cambarus. It is hooked as in the species of the *C. Blandingii* group. Perhaps it is *C. Wiegmanni* Erichs. The locality is interesting as being the most southern on record for the genus Cambarus.

1880–82. In the 57th Jahresbericht der Schles. Gesellsch. f. vaterl. Cultur, p. 202 (1879), it is recorded that Dr. Gustav Joseph exhibited a blind Cambarus, *C. typhlobius*, sp. nov., from the caves of Carniola, closely related to *C. pellucidus* from the Mammoth Cave, Kentucky. In a paper published in December, 1881, in the twenty-fifth volume of the Berliner Entomologische Zeitschr., the same writer again mentions the blind Crayfish by the name *Cambarus cœcus*, sp. nov. (p. 237), and *Cambarus Stygius*, sp. nov. (p. 249). In the twenty-sixth volume of the same journal, p. 12, April, 1882, Dr. Joseph gives a fuller account of this species under the name *Cambarus Stygius*. (See p. 45 of this Revision.)

1881. A new blind Crayfish from the Nickajack Cave, Tennessee, is described and figured by Cope and Packard in the American Naturalist, Vol. XV. pp. 877–882, Pl. VII. ("The Fauna of the Nickajack Cave"). This species is named *Orconectes hamulatus*. It resembles *C. pellucidus* in general form, but the external sexual parts are similar to those of the Cambari belonging to the *C. Bartonii* group. The authors surmise that *O. hamulatus* is derived from *C. latimanus*. Two type specimens have been presented to the Museum of Comparative Zoölogy by Professor Packard.

1882. Mr. C. L. Herrick, in the Tenth Ann. Rep. Geolog. and Nat. Hist. Surv. of Minnesota, pp. 253, 254, records *Cambarus virilis* Hagen from Minnesota, and describes as a new species *C. signifer*, from Hennepin County, in the same State. Types of both of Herrick's species have been procured through the U. S. National Museum and Mr. Herrick. The "new" species, *C. signifer*, does not differ from Hagen's *C. immunis* enough to be esteemed a different species, as was pointed out in Science, Vol. I. p. 15, 1883.

1882. "A List of the Crustacea of Wisconsin, with Notes on some new or little known Species," by W. F. Bundy, in Trans. Wis. Acad. Sci., Arts, and Letters, Vol. V. pp. 177–184. In this paper *C. Stygius*, *C. Wisconsinensis*, *C. debilis*, and *C. gracilis*, all of them Bundy's species, are again described. *C. acutus* Gir., *C. virilis* Hag., *C. propinquus* Gir., *C. placidus* Hag., *C. rusticus* Gir., *C. obesus* Hag., and *C. Bartonii* Erichs., are also included in the list as Wisconsin species, *C. rusticus* and *C. Bartonii* from Lake Superior.

1883. "The Crustacean Fauna of Wisconsin, with Descriptions of little known Species of Cambarus," by W. F. Bundy, in Geology of Wisconsin, Survey of 1873–79,

Vol. I. pp. 402–405. This paper is the same in substance as the last; but *C. placidus* Hag. is omitted from the list, and *C. Coucsi* Streets ? is added.

1883. The exhibition of living specimens of *Cambarus Bartonii* from North Grafton, Worcester Co., Mass., at the rooms of the Worcester Natural History Society, is recorded in "Scientific and Literary Gossip," Vol. I. p. 113. The only locality in this State hitherto known was Williamstown, in Berkshire Co. Through the kindness of Mr. F. G. Sanborn these specimens are now in the collection of the Museum of Comparative Zoölogy.

1884. In a note "On the so-called Dimorphism in the Genus Cambarus," in Amer. Journ. Sci., Vol. XXVII. pp. 42–44 (reprinted in Ann. and Mag. of Nat. Hist., 5th Ser. Vol. XIII. pp. 147, 148), I suggested that the two forms of the male Cambarus were alternating conditions of the same individual connected with the reproductive seasons, and not dimorphic forms, as was commonly supposed. (See p. 12.)

1884. Mr. Ralph S. Tarr describes in Nature, Vol. XXX. pp. 127, 128, the burrows of *C. Diogenes* Girard.

1884. Dr. C. C. Abbott, in the American Naturalist, Vol. XVIII. pp. 1157, 1158, takes exception to Mr. Tarr's conclusion that the mud chimneys built by *C. Diogenes* are the accidental result of the excavation of the burrows.

1884. Descriptions of the new species of Cambarus found during the preparation of this Revision, together with a synonymical list of the species of Cambarus and Astacus, were published by me in the Proceedings of the American Academy of Arts and Sciences, Vol. XX. pp. 107–158, December, 1884.

Dr. Hagen's Monograph must ever remain the foundation for all systematic work on the North American Astacidæ. The types of all his species are in the Museum of Comparative Zoölogy, and have been constantly before me in the preparation of the present Revision. With far ampler material at my disposal than fell to Dr. Hagen's lot, I have seldom had occasion to differ from him in his conclusions concerning the species known to him. Thirty-two species of Cambarus are described by Dr. Hagen. Of these, eleven are described as new species; viz. *C. fallax*, *Lecontei*, *versutus*, *lucifer*, *virilis*, *placidus*, *juvenilis*, *obscurus*, *immunis*, *extraneus*, and *obesus*. Of these, *C. placidus* and *C. juvenilis* are in my opinion only forms of the variable species *C. rusticus* Gir.; *C. obscurus*, a local variety of *C. propinquus* Gir. *C. obesus* is the same as *C. Diogenes* Gir. The remaining species included in Hagen's memoir are *C. acutus* Gir., *Clarkii* Gir., *troglodytes* (LeC.), *Blandingii* (Harlan), *spiculifer* (LeC.), *angustatus* (LeC.), *maniculatus* (LeC.), *penicillatus* (LeC.), *Wiegmanni* Erichs., *pellucidus* (Tellk.), *affinis* (Say), *propinquus* Gir., *rusticus* Gir., *Bartonii* (Fab.), *robustus* Gir., *Nebrascensis* Gir., *latimanus* (LeC.), *Mexicanus* Erichs., *Cubensis* Erichs., *advena* (LeC.), and *Carolinus* Erichs. *C. maniculatus*, *Nebrascensis*, *Mexicanus*, and *Cubensis* were known to Hagen only through the descriptions of the original authors of the species. *C. acu-*

tus Gir. I consider to be the Southern and Western form of *C. Blandingii* Harlan (= *C. acutus*, var. B, Hagen); *C. robustus*, a variety of *C. Bartonii*. By some error the descriptions of *C. advena* and *C. Carolinus* are transposed in Hagen's Monograph.

It is exceedingly difficult to discriminate between the different species of North American Cambari, even with the help of the most careful descriptions and figures, which are rarely afforded us by the older authors. It therefore becomes a matter of the first importance to examine type specimens whenever it is possible. In September, 1870, Dr. Hagen examined the types of some of Erichson's and De Saussure's Cambari in the Berlin Museum, and has kindly placed in my hands the notes which he took concerning them. Of Erichson's types he found the following: — *C. pellucidus*, a male, form I. *C. affinis*, a female from Carolina, collected by Dr. Cabanis. The locality is new. Cabanis informed Dr. Hagen that all the Cambari which he collected were taken in a rivulet in the northern part of South Carolina, near Greenville, at a farm called Tiger Hall. I suspect that this specimen may be the nearly related species *C. spinosus* Bundy. (See p. 87.) *C. Bartonii:* "Erichson's types are a male, form II., and young female from South Carolina, Cabanis, and, so far as I saw, both are the young of *C. latimanus*." *C. Cubensis:* "Three males, form I., and two females, agreeing with Erichson's description. It belongs probably to Group II." (See p. 51.) *C. Carolinus:* "Erichson's type, from South Carolina, Cabanis, is a male form I., and, so far as I saw, my *C. Bartonii*." Nevertheless, Erichson's description accords well with Hagen's *C. Carolinus*. (See p. 56.) The types of Erichson's two Mexican species, *C. Wiegmanni* and *C. Mexicanus*, could not be found in the Berlin Museum by Dr. Hagen, nor at a later day by Von Martens (Arch. f. Naturgesch., 1872).

The types of De Saussure's species, *C. consobrinus* from Cuba, *C. Azteeus* and *C. Montezumæ* from Mexico, were also examined by Hagen in Berlin. When the Monograph of the North American Astacidæ was written, Hagen had seen no specimens from Cuba or Mexico, and he fell into the error of supposing that the peculiar species *C. Montezumæ* was the same as Erichson's *C. Mexicanus*. This mistake was rectified on seeing Saussure's types. *C. consobrinus:* "Saussure's types, two females, dry. A peculiar species, or a young state of *C. Cubensis*. Rostrum bidentate." *C. Aztecus:* Saussure's types. The male, first form, and female, from Mexico, seem to be *C. Mexicanus* Erichs., with nearly cylindrical hands. The second form, with more

flattened hands, belongs alone, then, to Saussure's *C. Aztecus*. In the second form the antennal scale is more broadly truncate at the end, and the rostrum is a little different. These differences are not striking enough, however, to preclude the specific identity of the two forms.

Of the species of Cambarus described by American authors before the date of Hagen's Monograph, but few types are extant. The oldest known to me are Harlan's, 1830, 1835 (*A. Blandingii* Har., *A. Bartonii* Fab., *A. affinis* Say), preserved in the collection of the Academy of Natural Sciences of Philadelphia.

In 1850, Professor Lewis R. Gibbes enumerated, without describing, four species of Cambarus under the names *Astacus Bartonii* Fab., *A. affinis* Say, *A. Blandingii* Harlan, and *A. pellucidus* Tellk. Several specimens labelled by Gibbes in the collection of the Philadelphia Academy and in the Museum of Comparative Zoölogy prove that his identifications were often incorrect, and consequently the localities given by him cannot be taken as authoritative. Under the name of *A. Bartonii* Gibbes appears to have confounded three distinct species: *C. Bartonii* (Fab.), *C. latimanus* LeC., and *C. rusticus* Gir. (See p. 65.) The localities South Carolina and Alabama cited by Gibbes under *A. Bartonii* probably refer to *C. latimanus*. Gibbes's *A. affinis* is the true *A. affinis* of Say, as is shown by a specimen in the Philadelphia Academy's collection; but the locality, "Florida," attributed to this species in Gibbes's paper, undoubtedly belongs to some other species. A specimen in the Museum of Comparative Zoölogy, determined as *A. Blandingii* by Gibbes, is *C. troglodytes* (LeC.); and to this species Gibbes's habitat, "the low country of South Carolina," properly appertains

Girard in his Revision of the North American Astacidæ (Proc. Acad. Nat. Sci. Phila., 1852) enumerates twenty species of Cambarus, twelve of which are new. The diagnoses are in many cases insufficient for the identification of the species, and it therefore becomes highly important to fix the species through an examination of typical specimens. Two of the species in Girard's list, *C. fossor* (Raf.) and *C. Oreganus* (Randall), were unknown to Girard, and remain doubtful to the present day. *C. Gambelii* (types in the Philadelphia Academy) is an Astacus. The types of most of Girard's species were formerly in the collection of the Smithsonian Institution at Washington, whence they were transported by Dr. Stimpson to the Chicago Academy of Science, and there consumed in the great fire of 1871. Fortunately, before their destruction types of five of the eleven new Cambari and two

of the previously described species were examined by Dr. Hagen in the course of the preparation of his monograph; viz. *C. Clarkii* Gir., *C. propinquus* Gir., *C. montanus* Gir., *C. rusticus* Gir., *C. longulus* Gir., *C. Bartonii* (Fab.), and *C. affinis* (Say). Hagen proved the correctness of Girard's determination of Fabricius's and Say's species. Of Girard's new species, *C. montanus* appeared identical with *C. Bartonii*, and *C. longulus* was deemed by Hagen to be an accidental variety of *C. Bartonii*. A thorough search for Girard's types in the Smithsonian Institution made by myself in December, 1882, discovered one more species, *C. Pealei*, which proved to be large specimens, male and female, of *C. affinis* (Say). These (and *Astacus Gambelii* in the Philadelphia collection) are the only types of Girard's species now existing.

There are, however, in the Museum of the Academy of Natural Sciences of Philadelphia eight species labelled with Girard's names (followed in most cases by a question-mark) *and the localities quoted by Girard.* These specimens may be considered of almost equal authority with type specimens. They are the following: *C. Pealei? C. rusticus? C. montanus? C. propinquus? C. acutissimus? C. Diogenes? C. robustus*, and *C. Blandingii*. *C. Pealei?* is the same as the typical *C. Pealei* in the Smithsonian Institution (= *C. affinis*). *C. rusticus?* and *C. montanus?* are identical with the types of the same name examined by Hagen. "*C. propinquus?* Garrison's Creek, Sackett's Harbor," is *C. obesus* Hag., and "*C. Diogenes?* District of Columbia," is *C. propinquus* as determined from the type examined by Hagen. That an accidental transposition of labels has here taken place is evident from the localities given on the labels (*C. propinquus* is not found in the District of Columbia), and from the account of the characteristic habits and coloration of *C. Diogenes* given by Girard. Through this misplacement of labels, and through his ignorance of the peculiar habits of the "chimney crayfish," Hagen failed to see the identity of his own *C. obesus* and Girard's *C. Diogenes*. *C. acutissimus?* is the young of *C. acutus; C. robustus* may be considered a variety of *C. Bartonii; C. Blandingii* is not Harlan's species, but the one afterwards described by Le Conte as *A. troglodytes*. There remain in Girard's list, to be determined without the aid of types or authoritative specimens, the following: *C. acutus* Gir., *C. pellucidus* (Tellk.), *C. Carolinus* Erichs., *C. pusillus* (Raf.), *C. Nebrascensis* Gir. *C. pusillus*, whether it be the same as Rafinesque's species or no, is probably a small form of *C. Bartonii; C. Nebrascensis*, I think, may be a variety of *C. Diogenes*.

Types of six of Le Conte's species (described in 1855) are preserved in the Academy of Natural Sciences of Philadelphia: *A. troglodytes*, *A. spiculifer*, *A. fossarum*, *A. angustatus*, *A. latimanus*, and *A. advena*. The Museum of Comparative Zoölogy also possesses types of *A. troglodytes*, *A. spiculifer*, *A. fossarum*, *A. latimanus*, and *A. advena*. *A. fossarum* is not separable from *A. troglodytes*. Le Conte's *A. maniculatus* remains yet unknown. (See p. 29.)

The Two Forms of the Males. — In every species of Cambarus, of which many specimens have been examined, two forms of the adult male have been found, characterized by striking differences in the conformation of the sexual parts. In the form called the first by Dr. Hagen, the external organs peculiar to the male are more perfectly formed than in the "second form," where they have somewhat the shape seen in the young male. The peculiarities of each of these forms have been fully described by Hagen,* to whose monograph the reader is referred for details. No intermediate conditions between these two forms exist, and there is no fixed relation between them and the size of the individual, males of the second form being often larger than those of the first, or *vice versa*. They cannot, then, be considered developmental stages. Dr. Hagen interpreted the facts as a case of dimorphism, and surmised that the second form males were sterile individuals; but I have since shown that males of the first form after the breeding season may revert to the second form by moulting.† The two forms of the male Cambarus, instead of being dimorphic forms, are probably alternating conditions in the life of one individual, the first form being assumed during the pairing season, the second form during the interval between the pairing seasons. The second form is probably impotent; the testes are smaller than in the first form, the vasa deferentia shorter,‡ but I have had no opportunity as yet to examine their microscopic structure.

Indications of Hermaphroditism in Cambarus. — Perhaps the only recorded case of undoubted hermaphroditism in the Decapod Crustacea is that of the lobster (*Homarus vulgaris*) described and figured by F. Nicholls in 1730.§ In

* Pages 21, 22.

† On the So-called Dimorphism in the Genus Cambarus, by Walter Faxon. Amer. Jour. Sci., Vol. XXVII. pp. 42–44, January, 1884.

‡ See Hagen's Plate II.

§ An Account of the Hermaphroditic Lobster presented to the Royal Society by Mr. Fisher, examined and dissected, by F. Nicholls. Philosoph. Trans. Roy. Soc. London, Vol. XXXVI. No. 413, p. 290, 1730 (Abridgment, Vol. VII. Pt. III. p. 121, Pl. IV., 1731). For a general account of hermaphroditic and other anomalous conditions among the Crustacea, see Faxon, On Some Crustacean Deformities, Bull. Mus. Comp. Zoöl., Vol. VIII. No. 13, 1881

this specimen the right half of the body was female, the left half male, as regards both internal and external organs.

Von Martens* has given an account of three specimens of a Cheraps with openings in the basal segment of the third pair of legs (the position of the sexual apertures of the normal female) co-existing with the male orifices in the first segment of the fifth pair of legs. No ovary or duct leading to the openings in the third pair of legs was detected; but as the specimens had lain in alcohol some seven years, the evidence against the existence of any internal female organs cannot be taken as positive. Similar openings were seen also in the third pair of legs of male *Parastacus pilimanus* and *P. Brasiliensis*.†

Among the vast number of Astacidæ that passed through my hands in the preparation of this memoir, I have noted four specimens, all of them Cambari, that combine external structures of the two sexes.

The first is a specimen of *C. propinquus*, var. *Sanbornii* Faxon, 60 millimeters long (M. C. Z., No. 3350). The general shape of the body with its broad abdomen, and the form of the claw, are as in the female; there are no hooks on the third pair of legs; the appendages of the first and second abdominal somites agree with those of the female, and there is a well-formed, though not prominent, annulus ventralis; the external opening of the generative system, on the contrary, is situated upon a small papilla at the base of the fifth pair of legs, exactly as in the male sex.

The second specimen also belongs to *C. propinquus*, var. *Sanbornii*. It is a young specimen, only 38 millimeters in length (M. C. Z., No. 3588). The first abdominal appendages are formed as in all young males of this species, but the sexual apertures are situate on the basal segment of the third pair of legs, and have the same appearance as in the normal female; there is also a well-formed annulus ventralis, and there are no tubercles on the third segment of the third pair of legs. The second pair of abdominal appendages are not at all transformed, but agree with the same appendages of the normal female.

The third specimen is a *C. Diogenes* Girard, from New Orleans, La., 84 millimeters long (M. C. Z., No. 242). It has all the external characters of the female, excepting the first pair of abdominal appendages, which are

* Sitzungsber. Gesellsch. naturforsch. Freunde zu Berlin, 18 Jan., 1870.

† E. Rousseau and E. Desmarest (Ann. Soc. Ent. de France, 2e Série, Tom. VI. p. 479, Pl. XIII., Tom. VI. p. 481, 1848) have recorded cases of *Astacus fluviatilis* with two pairs of sexual orifices, one on the third, the other on the fourth pair of legs; but in these specimens both pairs of orifices were vulvæ leading to the ovaries by a branched duct on each side of the body.

curiously modified so as to resemble the same parts in the males of the genus Astacus. The transverse suture near the base of the appendage is obliterated; the apical half, instead of being membranous and fringed with setæ, as in the normal female, is firm and naked, and rolled from the outside inward so as to form on the inner side a groove which is converted into a tube just at the tip, owing to the closeness of the coil at that point. The whole organ is larger and thicker than in the ordinary female, although not so large as in the male. The tip is altogether destitute of the recurved hooks of the normal male organ in this species.

The fourth specimen belongs to *C. propinquus* Girard. It is 72 millimeters long (M. C. Z., No. 3432). It agrees with the female in every respect except the shape of the first pair of abdominal limbs, which are partly transformed into the condition which obtains in the male. The modification of the appendages has not gone so far on the right side as on the left. In both, the transverse suture is obliterated; the basal half is thick and corneous, and produced into a prominent tubercle on the inner side, as in the male. The apical half of the right appendage retains the membranaceous and setiferous character of the female appendage, while in the left it is more corneous, and rolled from without inwards in such a fashion as to form an inner and an outer part somewhat as in the male, though neither part is in this case produced into an acute style, as in the normal male, and the outer part retains the membranaceous setiferous tip.

These specimens are in such a bad state of preservation that a determination of the sex from the internal generative organs in several of them is wellnigh impossible. Dissection of the first-described specimen, with the orifices of the generative organs in the base of the last pair of legs, as in the male, revealed many large ovarian eggs, and I little doubt that the other three individuals are females which have assumed some of the characters of the opposite sex.* It would be interesting to determine from fresh specimens whether such monstrous conditions as those just described ever denote true hermaphrodites, producing both male and female generative elements, or whether they may involve sterility. They are the more interesting from the fact that hermaphroditism exists as a normal condition in another highly specialized order of Crustacea, the Isopoda.†

* Boas (Vidensk. Selsk. Skr. 6te Raekke, naturvidensk. og Math. Afd., Bd. I. pp. 94, 184) says he has seen a female *Thalassina anomala* and a female *Astacus fluviatilis* with abdominal appendages like the male, but gives no particulars concerning these specimens.

† See Bullar, Journ. Anat. Physiol., Vol. XI. p. 118, 1876; Ann. Mag. Nat. Hist., 4th Ser., Vol. XIX. p. 254, 1877; and P. Mayer, Mitth. Zoolog. Station zu Neapel, Vol. I. pp. 165, 177, 1878.

Peculiarities of the Young Stages of Cambarus. — The young Cambarus, like the young Astacus, when it leaves the egg is devoid of appendages on the first and sixth abdominal somites. The telson is not divided by a transverse suture. I have examined specimens of *C. rusticus* when but four millimeters in length, evidently just released from the egg. They have much the same appearance as the embryo of *Astacus fluviatilis* just before hatching, as figured by Rathke.* The cephalothorax is very large in proportion to the abdomen, and spherical; the rostrum is bent down between the eyes; the antennæ are laid back closely upon the breast. All of the appendages are soft, weak, and flexed beneath the sternum. There is no vestige of a gill on the last thoracic somite any more than in the adult Cambarus. The telson is a thick oval plate, entirely destitute of marginal setæ, such as are seen fringing the telson in recently hatched young of Astacus figured by Huxley on page 220 of "The Crayfish"; agreeing in this respect with the telson of the embryo of Astacus as shown in Plate II. fig. 25, of Rathke's memoir. I have no doubt that the newly hatched young of Astacus figured by Huxley has undergone one ecdysis since leaving the egg, whereby the embryonic cuticle has been discarded.

Young specimens of *C. Clarkii*, seven millimeters long, taken from under the abdomen of the parent, have acquired the general form of the adult. The swimmerets, or posterior abdominal appendages, are well developed, while in the European *Astacus pallipes*, ten days old and eleven millimeters in length, these appendages are enclosed within the notched telson, from which they are set free after the second or third moult, judging from specimens received from the Collége de France. Specimens of *C. gracilis*, nine millimeters long, and *C. Bartonii*, ten millimeters long, still under the protection of the parent, have the swimmerets perfectly expanded, and even show the transverse suture of the telson. It seems probable, from a comparison of these Cambari with the young of European Astaci, that the development of the former goes on more rapidly after leaving the egg than that of the latter.

It is interesting to observe that in the young *C. Clarkii* above mentioned the areola is moderately wide in the middle, where it is reduced to a line in the adult; the lateral spines of the rostrum are well developed, the acumen long and acute. In all the recently hatched Cambari which I have seen, the legs and claws are long and slender compared with the adult.

* Untersuchungen über die Bildung und Entwickelung des Flusskrebses, Tab. I. fig. 16, Tab. II. fig. 25.

It has been noted already that in the young stages of Cambarus and Astacus the first abdominal appendages are wanting, and the telson is not divided by a transverse suture. In these respects the young stages agree with the adult condition of the Parastacinæ. On this account, and on account of the more generalized arrangement of the gills in the Parastacinæ,* it would seem that the Potamobiinæ are a more specialized type than the Parastacinæ. Further, among the Potamobiine crayfishes the genus Cambarus will hold the highest place by reason of the complete suppression of the pleurobranchiæ and the high degree of specialization exhibited in the first abdominal appendages and hooked thoracic legs of the males and the annulus ventralis of the female. In the abnormal female of *Cambarus Diogenes*, noticed on page 13, it is clearly demonstrated that an organ essentially like the first abdominal appendage of Astacus is the first step in the transformation of the common type of abdominal limb into the male appendage of Cambarus. The three species of Cambaroides (p. 126) form a passage from Cambarus to Astacus proper.

Division of the Species of Cambarus into Subordinate Groups. — Girard divided the Cambari into three groups, based upon the form of the rostrum and the anterior pair of abdominal legs in the male. Dr. Hagen also concluded that the genus comprehended three well-defined groups, but he based his division of the genus upon the number of hooked thoracic legs in the male, taken in connection with the shape of the rostrum (whether toothed or toothless). It follows that the groups of these authors do not exactly coincide; e. g. *C. pellucidus* falls into the same assemblage of species with *C. affinis*, *C. rusticus*, etc., in Girard's system, whereas by Hagen's mode of division it is associated with *C. Blandingii* and allied species. It seems to me that we get a more natural grouping of the species by taking the number of hooked thoracic legs in connection with the structure of the first pair of abdominal appendages of the male as the basis for the division of the genus, without reference to the form of the rostrum. Any division based wholly or in part upon the presence or absence of lateral rostral spines will divorce species which in the totality of their organization are most closely related. If it be urged against this mode of division that it implies a knowledge of the peculiarities of one sex, I reply that the same objection applies to the groups of Girard and Hagen, which are based in part upon characters found only in

* In all the Parastacinæ, except *Astacoides Madagascariensis*, there are four pleurobranchiæ developed, and the whole number of gills is twenty or twenty-one.

the male. If the reader is unable to determine the group to which the specimens in his hands belong, through the lack of males, the fault lies, as Dr. Hagen observes, not in the principle of classification, but in the scantiness of his material. A species involves two sexes; and until the species is known, it avails little to attempt the determination of a specimen in this difficult genus.

In accordance with the above principle of division, the genus Cambarus falls into five subordinate groups, viz.: —

I. Third segment of third and fourth pairs of legs of male hooked. First pair of abdominal appendages of male with outer part truncate at the tip, with one to three recurved teeth; inner part terminated by a short acute spine, which is generally directed outwards. Type, *C. Blandingii*.

II. Third segment of third pair of legs of male hooked. First pair of abdominal appendages of male as in Group I. Type, *C. advena*.

III. Third segment of third pair of legs of male hooked. First pair of abdominal appendages of the male thick, terminated by two recurved teeth, the larger of which is formed by the tip of the outer part of the appendage, the smaller by the inner part. Type, *C. Bartonii*.

IV. Third segment of third pair of legs of male hooked. First abdominal appendages of male terminating in two elongated, nearly straight, acute tips. Type, *C. affinis*.

V. Third segment of second and third pairs of legs of male hooked. Type, *C. Montezumæ*.

GROUP I. (Type, C. Blandingii.)

Third segment of third and fourth pairs of legs of male hooked. First pair of abdominal appendages of male with outer part truncate at the tip, and furnished with one to three small recurved teeth; inner part terminated by a short acute spine, which is generally directed outwards.

In this group the rostrum is generally triangular, with a small tooth on each side, near the apex; in *C. Lecontei*, *C. spiculifer*, *C. versutus*, and *C. pubescens*, the lateral teeth are more strongly developed. The chelæ are slender and covered with flattened, squamous tubercles, ciliated in front. The male appendages are tipped with two or three small curved teeth (corneous in the first form), and armed on the inside with a sharp spine directed obliquely or horizontally outwards. The terminal teeth are very minute in *C. fallax*.

The section of the carapace behind the cervical groove is more than half as long as the distance from the cervical groove to the tip of the rostrum, as in *C. Blandingii*, etc., or much less than half this distance, as in *C. versutus*, etc. In *C. spiculifer*, *C. versutus*, and *C. pubescens*, the areola is broad, as in the genus Astacus. In the majority of the species of Cambarus the areola is narrow, or even obliterated by the close approximation of the branchio-cardiac lines in the median line of the back, as in *C. Diogenes*, *C. Clarkii*, etc. The narrowing of the areola involves an increase in height of the branchial chambers, for the so-called branchio-cardiac lines which form the lateral boundaries of the areola denote the upper limit of the branchial chamber where the lining membrane of the carapace is continued into the lateral wall of the thorax. This increase in the height of the branchial chamber which generally obtains in the genus Cambarus may perhaps be explained as a means to allow an increase in the length of the branchiæ in compensation for the diminution in number. The broad areola which accompanies the more generalized gill formula of Astacus may be considered the more primitive form. In accordance with this view, it appears that in species of Cambarus with very narrow or linear areola, as *C. Clarkii*, the very young stages of growth display an appreciably wider areola.

The antennal scale in the species of Cambarus belonging to the first group is commonly broadest toward the base or at the middle.

The most aberrant species of the group are *C. penicillatus*, *C. Alleni*, and *C. pellucidus*. In *C. penicillatus* and *C. Alleni* the rostrum is devoid of lateral teeth, the spine that terminates the inner part of the first abdominal appendages of the male is long and erect, the terminal teeth minute. In *C. penicillatus* the antennal lamina is short, and broad toward the tip. The blind *C. pellucidus*, from the caves of Kentucky and Indiana, is the most peculiar species of the group. The sides of the rostrum are sub-parallel from the base to the lateral spines, the acumen long; the antennal scales are broadest at the distal end; the portion of the carapace which lies in front of the cervical groove is very short compared with the hinder section. The first pair of abdominal appendages of the male are hardly specialized to a greater degree than in the genus Astacus, the tips of the organs being simply produced into two small processes, the one representing the spine that terminates the inner part of the appendage in the more normal species of the group, the other the teeth of the outer part. In the first form of the male the latter process is corneous. The appendage, as a whole, is more closely rolled than

in the genus Astacus, and in its general form agrees with the corresponding limb in the other Cambari. Remarks on the relations of this interesting species will be found on page 42.

I am disposed to regard the Cambari of this group as, on the whole, the lowest forms in the genus. The slight degree of specialization of the external male appendages, the tendency toward an oval, astacoid form of body, the slender claws and generally toothed rostrum, all point to this. That the stout-clawed species with toothless rostrum are derived from forms with slender chelæ and toothed rostra seems probable from the fact that the latter characters are commonly found in very young individuals of all species.

This group corresponds exactly with Group I. of Hagen's Monograph.

Rostrum toothed.	Section of the carapace behind cervical groove long (see p. 18).	Epistoma rounded in front: *C. Blandingii, C. Hayi, C. fallax.**
		Epistoma truncate: *C. Clarkii, C. troglodytes.*
	Posterior section of carapace short (see p. 18).	Areola narrow: *C. Lecontei.*
		Areola wide: *C. spiculifer, C. versutus, C. angustatus, C. pubescens.*
	Eyes atrophied: *C. pellucidus.*	
Rostrum toothless.	*C. Wiegmanni, C. penicillatus, C. Alleni.*	

1. Cambarus Blandingii.

Plate VII. figs. 2, 2′, 2″, 2 a, 2 a′ (first abdominal appendages of male).

Astacus Blandingii, Harlan, Trans. Amer. Philosoph. Soc., III. 464, 1830.—Medical and Physical Researches, p. 229, fig. 1, 1835.

Astacus Blandingii, Milne Edwards, Histoire Naturelle des Crustacés, II. 332, 1837. (After Harlan.)

Astacus Blandingii, De Kay, Zoölogy of New York, Part VI. Crustacea, p. 23, 1844. (After Harlan.)

Astacus (*Cambarus*) *Blandingii*, Erichson, Arch. f. Naturgesch., Jahrg. XII., I. 98, 1846. (After Harlan.)

? *Astacus Blandingii*, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 400, 1855.

Cambarus Blandingii, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III., 43, Pl. I. figs. 63, 64, Pl. III. fig. 140, 1870.

Cambarus acutus, var. B, Hagen, *op. cit.*, p. 36, Pl. III. fig. 144, 1870.

Cambarus acutus, Abbott, Amer. Naturalist, VII. 80, 1873. (Habits.)

Cambarus acutus (in part), Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 637, 1874. (After Hagen and Abbott. No description.)

Cambarus Blandingii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 135, 1884.

Known Localities.†—New York. New Jersey: Essex Co.; Delaware River and tributaries, near Trenton. Maryland: Baltimore Co. (Coll. P. R. Uhler);

* In some specimens of *C. fallax* the hinder section of the carapace is a little less than one half the distance from the cervical groove to the tip of the rostrum. *C. maniculatus* (LeC.) is omitted from the above table, as I have seen no specimens answering to the description of Le Conte.

† Localities for which no authority is given in parentheses are represented in the collection of the Museum of Comparative Zoölogy.

Caroline Co. (Coll. P. R. Uhler); Dorchester Co. (Coll. P. R. Uhler); St. Mary's Co. (Coll. P. R. Uhler); Somerset Co.; Wicomico Co. (Coll. P. R. Uhler); Worcester Co. Virginia: James River (Coll. Acad. Nat. Sci. Phila.); Lunenburg (Coll. L. A. Lee). North Carolina: Tarboro (Coll. U. S. Nat. Mus.); tributaries of Neuse River, Goldsboro (P. R. Uhler); Kinston; Beaufort; Salmon Creek (Coll. U. S. Nat. Mus.); Wilmington (Coll. U. S. Nat. Mus.). South Carolina: Camden (Coll. Acad. Nat. Sci. Phila.); Saluda River (Coll. Butler Univ.); Columbia. Georgia: Richmond Co.

Var. **acuta.**

Cambarus acutus, Girard, Proc. Acad. Nat. Sci. Phila., VI. 91, 1852.
Cambarus acutissimus, Girard, *loc. cit.*, 1852.
Cambarus acutus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III., 35, Pl. I. figs. 1–5, Pl. II. figs. 106, 108, 110–114, 116, 118, 120–124, 126, 127, Pl. III. fig. 143, 1870.
Cambarus acutus, var. A, Hagen, *op. cit.*, p. 36, Pl. II. figs. 107, 109, 115, 117, 119, 125, 1870.
Cambarus acutus (in part), Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 637, 1874. (After Hagen. No description.)
Cambarus acutus, Forbes, Bull. Ill. Mus. Nat. Hist., No. I., 3, 18, 1876.
Cambarus acutus, Bundy, Trans. Wis. Acad. Sci., V. 180, 1882. — Geol. Wis., Surv. 1873–79, I. 402, 1883. (No description.)
Cambarus Blandingii, var. *acuta*, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 136, 1884.

Known Localities. — Louisiana: New Orleans; Amite City, Tangipahoa River (Coll. U. S. Nat. Mus.); Tickfaw (Coll. U. S. Nat. Mus.). Mississippi: near Vicksburg; Kemper Co., tributary of Tombigbee River (Coll. Acad. Nat. Sci. Phila.). Alabama: Mobile; Blount Spring, Blount Co. (Coll. U. S. Nat. Mus.); Cullman, Cullman Co. (Coll. U. S. Nat. Mus.); Decatur, Morgan Co. (Coll. U. S. Nat. Mus.); Bridgeport, Jackson Co., in pond formed by overflow of Tennessee River. South Carolina: Beaufort (Coll. Acad. Nat. Sci. Phila.); Charleston. Tennessee: Memphis (Coll. O. P. Hay). Missouri: St. Louis. Illinois: Athens, Menard Co. (Coll. Peabody Acad. Sci.); Decatur, Macon Co.; Pekin, Tazewell Co. (S. A. Forbes); Normal, McLean Co. (Peabody Acad. Sci.); Oquawka, Henderson Co. (Coll. O. P. Hay); Peoria, Peoria Co.; Lawn Ridge,* Marshall Co.; Evanston, Cook Co. Indiana: Wheatland, Knox Co. Iowa: West Liberty; Dubuque (Peabody Acad. Sci.). Wisconsin: Racine (W. F. Bundy); Sauk City (W. F. Bundy).

Harlan's type is still preserved in the collection of the Academy of Natural Sciences of Philadelphia, and has been well described by Hagen. It came

* The localities "Basson Ridge" and "Basson Pudge," given by Hagen (pp. 37, 39, 97, 102), are false readings of the MS. label "Lawn Ridge."

from Camden, a town near the Wateree River, Kershaw Co., S. C. Compared with Girard's *C. acutus*, from farther south, the rostrum is longer, with longer acumen; carapace smoother, although granulated on the branchial regions; lateral thoracic spine prominent; antennal scale longer and much narrower; hand longer, more cylindrical, the squamous tubercles not tending to form a definite line of teeth on the inner margin, as in *C. acutus*. Harlan says, "All the crawfish which I have seen from the Southern States (and I have received specimens from New Orleans and South Carolina) are of the same species with that now described."* It is probable that he included in this species not only *C. acutus*, but also other allied species, as *C. troglodytes*, &c.

Among specimens collected for the U. S. National Museum by Col. M. M. McDonald in the neighborhood of Columbia, S. C., (a city thirty-two miles southwest of Camden, in the same river basin,) are several which nearly resemble Harlan's type. They are younger, and the males are all of the second form, with small chelæ. The antennal scale is somewhat broader than in Harlan's specimen. Lateral thoracic spine well developed. The largest male is $3\frac{1}{4}$ inches in length, chelipeds $2\frac{3}{8}$ inches.

In the collection of Butler University, Irvington, Ind., there is a first form male of the same species from the Saluda River, S. C., collected by Prof. D. S. Jordan. The Saluda River unites with the Broad River at Columbia to form the Congaree. The chelipeds have been lost. The antennal scale is somewhat broader than in Harlan's type, but in other respects, including the form of the anterior abdominal appendages, it agrees with it. Length, 3 inches.

In specimens from the low country of North Carolina, Maryland, and New Jersey, the rostrum narrows nearer the base, and the hand is closely set with ciliate squamous tubercles. In some individuals from North Carolina the cardiac region of the carapace is shorter in proportion to the anterior portion than in the ordinary form (less than one half the distance from tip of rostrum to the cervical groove).

Cambarus acutus of Girard, from the South and West, is a larger form, with quite a differently shaped hand and rostrum and a shorter abdomen; but after a careful study of a very large number of specimens from the Atlantic and Gulf States and the Mississippi Valley, I am inclined to consider them forms or varieties of one species. The male sexual appendages

* Trans. Amer. Philosoph. Soc., III. 465.

are the same in all essential regards, and specimens intermediate in the form of the hands, rostrum, and antennal scale are frequently met with.

Two dry male specimens in the Museum of the Academy of Natural Sciences of Philadelphia, from Kemper Co., Miss., labelled "*C. acutissimus*?" are probably types of the species described under that name by Girard. They appear to be young specimens of *C. acutus*.

The specimens of *C. Blandingii*, var. *acuta*, received from the Western States differ somewhat from those of the Southern States, as pointed out by Hagen on page 36 of the Monograph of the North American Astacidæ. They form a sub-variety designated by the letter A.

Dr. Hagen considers Le Conte's *A. Blandingii* to be his *C. Lecontei*. No type of Le Conte's species is known, but the description and habitat (middle regions of Georgia and Carolina) fit *Blandingii* better than *Lecontei*.

Gibbes and Girard seem to have confounded this species with *C. troglodytes*. There is a specimen of *C. troglodytes* in the Museum of Comparative Zoölogy, sent by Gibbes with the label "*Astacus Blandingi* Harl.," and the localities given by him,* viz. "the low country of South Carolina," and by Girard, viz. "Summerville, S. C.," refer to *C. troglodytes*.

From Montgomery, Ala., comes a form which agrees with *C. Blandingii* in all respects except the male sexual appendages, which approach those of *C. Lecontei* in the curvature of the two anterior apical teeth. The posterior apical tooth is straight, as in *C. Blandingii*. In many of the larger specimens there are three spines on each side of the telson. This may perhaps prove to be a distinct species.

Two female specimens in the Museum of Comparative Zoölogy, from Dallas, Texas, agree well with *C. Blandingii*, but it is difficult to determine them positively in the absence of male specimens. They were collected by J. Boll, and are labelled "Burrowing Crabs."

In specimens of var. *acuta*, subvar. A, from the West, that have not lain long in alcohol, the rostrum is red (in some specimens only a pair of red blotches at the base), and there appears a good deal of red color on the dorsal side of the abdominal segments and the basal segment of the telson and swimmerets. Living specimens of *C. Blandingii* collected by me near Trenton, N. J., are of a dull greenish brown, whitish beneath and on the lower part of the carapace, with a dark-greenish longitudinal stripe on each

* On the Carcinological Collections of the Cabinets of Natural History in the United States. Proc. Amer. Assoc. Adv. Sci., pp. 167–201, 1850.

branchial region, half-way between the areola and the lower border, and a whitish longitudinal band on each side of the abdominal somites, these bands not reaching to the hind border of the somites. The tubercles of the chelæ are black, and there are dark spots on the margin of the rostrum.

Dr. Abbott* states that in Trenton, N. J., this species frequents "running streams which have masses of vegetation growing in them, the animal in question resting upon the plants, usually near the surface of the water. We have found since our collecting excursions, on carefully approaching clear running streams, such as just mentioned, that this crawfish is to be seen resting on the plants, always with the head directed above stream. If disturbed, they would dart backwards down to the roots, apparently, of the plant upon which they were sitting. After a lapse of about ten minutes, they would return to their former resting-place, creeping up the plant down which they had so suddenly darted tail foremost."

Mr. P. R. Uhler, in his studies on the distribution of the crayfishes of Maryland, finds that this species belongs to the lowlands at the mouth of sluggish rivers, or near the ocean in muddy and grassy ditches and drains, and even in salt water, in company with *C. Uhleri*. In his collection are specimens from near Ocean City, Worcester Co., Md., found in a ditch in holes six to nine inches deep. At Goldsborough, N. C., the same gentleman found it abundant in drains and branches running through cotton fields, tributaries of the Neuse River.

C. Blandingii, var. *acuta*, attains a very large size. The largest I have seen, a male of the first form, is $5\frac{1}{8}$ in. in length. The cheliped is $6\frac{7}{8}$ in., the chela $3\frac{7}{8}$ in. This specimen is in the Museum of Comparative Zoölogy.

2. Cambarus fallax.

Plate II. fig. 4.

Cambarus fallax, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 45, Pl. I. figs. 103–105, 1870.
Cambarus fallax, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 136, 1884.

Known Localities. — Florida: St. John's River at Jacksonville, Orange Bluff, Hawkinsville, Horse Landing, Blue Spring (Coll. Peabody Acad. Sci.), and Lake Jessup (Coll. U. S. Nat. Mus.); Magnolia (Coll. Boston Soc. Nat. Hist.); Indian River (Coll. U. S. Nat. Mus., Yale Coll.); Titusville, Brevard Co. (Coll. U. S. Nat. Mus.).

* Amer. Naturalist, VII. 80.

The four type specimens, collected by Dr. H. Bryant, are 1 ♂ form I., 2 ♂ form II., 1 ♀. The measurements given by Hagen are those of the largest specimen, ♂ form II. This is the largest specimen I have seen. *C. fallax* is very near *C. Blandingii*, which it seems to replace in the State of Florida. It is easily distinguished from the latter species by the male appendages, which are curved backwards at the end, and armed with only minute teeth at the tip. The distal margin of the proximal segment of the telson is armed on each side with three or four spines. In a few specimens from Hawkinsville, St. John's River, Fla., the acumen of the rostrum is lengthened, the lateral spines of the rostrum are stronger, and the portion of the carapace behind the cervical suture is shortened. The specimens thus approach *C. Lecontei*. The shortening of the posterior part of the carapace is not so great as in *C. Lecontei*, the areola is narrower, and the male appendages do not differ from those of the typical *C. fallax*. In the ordinary form of *C. fallax* the distance from the tip of the rostrum to the cervical groove is twice the distance from the cervical groove to the hind border of the carapace. In the abnormal specimens just noticed the anterior distance is two and one third times that of the posterior; in *C. Lecontei* it is two and one half times. In many specimens, contrary to Hagen's description, the antennæ are much longer than the body, and in well-developed males of the first form the chelæ are inflated and cylindrical. Specimens of this species, now in the Museum of the Peabody Academy of Science, Salem, were collected by C. J. Maynard, in Blue Spring, St. John's River, a mineral spring impregnated with sulphur and magnesia, — temperature 70° Fahr. They were clinging to the under side of leaves.

3. Cambarus Hayi.

Plate I. fig. 4, Plate VII. figs. 3, 3′, 3a, 3a′.

Cambarus Hayi, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 108, 1884.

Male, form I. Rostrum broad, triangular, excavated, sparsely pubescent above; acumen short, lateral spines moderate. Carapace punctate above, granulated on the sides, the granules ciliate. Lateral spines slightly developed in fully-grown individuals, more prominent in the young. Areola narrow. Abdomen broad, shorter than the cephalo-thorax. Pleural angles rounded. Proximal segment of telson with two spines on each side of the distal border. Hind margin of telson slightly concave. Anterior process

of epistoma broadly triangular. Antennæ shorter than the body. Antennal scale a little shorter than the peduncle, equal to the rostrum, broad, broadest at the middle. Chelipeds slender, chela long, inner and outer margins parallel, squamoso-tuberculate, tubercles ciliate, those along the inner margin of the hand blunt spiniform. Fingers longer than the hand. Opposed margins of fingers ciliate, with one or two small spinous teeth. Carpus long triangular, smooth without, tuberculate and spinous within. Meros with scattered impressed dots without, tuberculate on the upper margin; one or two spines at the anterior end of upper margin, two rows of spines beneath. Third and fourth pairs of legs hooked on third segment. Anterior abdominal legs of moderate length, deeply excavated on the outer side near the tip; a beard-like tuft of cilia from the protuberance behind the excavation; the tip bears three flattened horny teeth; inner part ciliate, with a long spine directed outwards and forwards.

The second form of the male has shorter chelipeds, smaller hooks on the second and third pairs of legs, the terminal teeth of the first pair of abdominal legs smaller and not corneous.

In the female the chelipeds are short, the chelæ broad. Sternum bituberculate between the fourth pair of legs. Annulus ventralis umbilicoid, with a tubercle in the median depression.

Length, 100 mm. Rostrum, 15 mm.; acumen, 3 mm. Length of carapace, 51 mm. From cervical groove to posterior margin of carapace, 18.5 mm. Abdomen, 50 mm. Width of areola, 1.5 mm. Chelipeds, 92 mm. Chela, 43 mm.

Known Localities. — Mississippi: Macon, Artesia.

Closely related to *Cambarus Blandingii*, but easily distinguished by the first pair of abdominal legs of the male, which are characteristic even in very small specimens. Over a dozen specimens of this species (including males of the first form, males of the second form with first pair of abdominal appendages articulated near the base, and unarticulated, and females) were collected by Prof. O. P. Hay in Eastern Mississippi. One lot has a particular locality specified, — Macon. Macon is situated on the Noxubee, an affluent of the Tombigbee River. Another lot was collected at Artesia, a town about twenty miles north of Macon.

4. Cambarus Clarkii.

Cambarus Clarkii, Girard, Proc. Acad. Nat. Sci. Philad., VI. 91, 1852.
Cambarus Clarkii, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 39, Pl. I. figs. 7–10, 99, 100, Pl. II. figs. 133, 134, Pl. III. fig. 142, Pl. IV. (this figure is copied on a reduced scale in Huxley's "Crayfish," p. 248, 1880), 1870.
Cambarus Clarkii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 136, 1884.

Known Localities. — Texas: between San Antonio and El Paso del Norte (Girard); San Antonio; Clear Creek, Waller Co. (Coll. U. S. Nat. Mus.). Louisiana: New Orleans; Tangipahoa River (Coll. U. S. Nat. Mus.). Mississippi: Ocean Springs, Jackson Co. (Coll. U. S. Nat. Mus.). Alabama: Mobile. Florida: Pensacola (Coll. U. S. Nat. Mus.); three miles below Horse Landing, St. John's River. Ohio: Olmsted [?].

Girard's specimens were collected between San Antonio, Texas, and El Paso del Norte, by John H. Clark, of the U. S. Mexican Boundary Commission. The original description of the species is hardly sufficient for determination, but fortunately Dr. Hagen was able to identify the species by an examination of Girard's types, which were probably lost in the great fire at Chicago, whither they were sent to Dr. Stimpson. A full description of *C. Clarkii* is given on page 39 of Hagen's Monograph.

In specimens collected by Edward Palmer at San Antonio, Texas, the carapace is smoother than in the form commonly received from New Orleans and Mobile, with more prominent lateral and postorbital spines. The rostrum tapers much less than in the form from farther east, the sides being more nearly parallel. The areola, moreover, is not entirely obliterated in the middle, but forms a linear area about as wide as in *C. troglodytes*. The male sexual appendages do not differ from those of the Louisiana specimens. This is probably the form described by Girard.

In this connection it is interesting to note that in young individuals of this species eight millimeters long, taken from beneath the abdomen of a female from New Orleans, the areola is proportionally even wider than in the San Antonio specimens.

In a male, form II., 60 mm. long, collected by J. A. Allen in St. John's River, Fla., the areola is like that described in the San Antonio specimens, and the distal margin of the proximal segment of the telson is armed with three or four spines on each side. The carapace is smooth.

A female specimen, 92 mm. long, in the Academy of Natural Sciences of Philadelphia (No. 654), from the Smithsonian Institution, without locality,

differs in some respects from any other seen by me. The granules of the carapace are larger, the gastric area more heavily punctate, the rostrum is longer (14 mm., the whole carapace being 48 mm., while in New Orleans specimens the rostrum is only one fourth the length of the carapace), with longer acumen and lateral spines, and narrower at the base, than in New Orleans specimens, with less converging sides; the arm is more conspicuously tuberculated along its upper edge. The lateral thoracic spines are prominent, as in the San Antonio form. The areola is obliterated in the middle, as in specimens from Louisiana and Alabama.

A dry cephalothorax of a female in the Museum of Comparative Zoölogy (No. 3337), referred to *C. troglodytes* by Hagen (pp. 42, 43), seems to belong to *C. Clarkii*. As dry specimens are easily transposed, and this is the only specimen recorded from the North, I believe the locality to be erroneous.

C. Clarkii is the species commonly on sale in the New Orleans market.

5. Cambarus troglodytes.

Astacus troglodytes, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 400, 1855.
Astacus fossarum, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 401, 1855.
Cambarus troglodytes, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 41, Pl. I. figs. 11–14, Pl. II. fig. 141, 1870.
Cambarus troglodytes, Forbes, Bull. Ill. Mus. Nat. Hist., No. I. pp. 4, 18, 1876. (After Hagen.)
Cambarus troglodytes, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 136, 1884.

Known Localities. — Lower Georgia; Richmond Co., Ga. South Carolina: Charleston; Oakley (Coll. U. S. Nat. Mus.); Columbia (Coll. U. S. Nat. Mus.). Illinois: Lawn Ridge, Marshall Co. [?].

This species resembles *C. Clarkii* very closely, but is readily distinguished by the first pair of abdominal legs of the male, and by the rostrum, which is nearly plane above, with very slight marginal teeth (often obsolete), and shorter acumen. The areola is very narrow, but not obliterated, in the middle.

Two of Le Conte's types (both males, form I.) are extant, one in the Museum of Comparative Zoölogy, and one in the Academy of Natural Sciences of Philadelphia. In each of these museums there is also a small female type of *C. fossarum* of Le Conte, which does not differ essentially from *C. troglodytes* of the same author. It is difficult to see why Le Conte separated the two, unless on the ground of a difference in color during life.

Both Girard and Gibbes (Proc. Amer. Assoc. Adv. Sci., 3d Meeting) appear to have confounded this species with *C. Blandingii* Harlan. A female *C. troglodytes* in the Museum of Comparative Zoölogy, from South Carolina, is labelled "*Astacus Blandingi* Harl." by Professor Gibbes. The localities for *C. Blandingii* (Summerville, S. C., and low country of South Carolina) given by these authors undoubtedly appertain to *C. troglodytes*.

Slight differences between specimens from Georgia and Charleston, S. C., are pointed out by Hagen (pp. 42, 43). In one of the Georgia specimens the telson is quadrispinose. In specimens from near Columbia, S. C., the basal segment of the telson is bispinose on each side.

The rostrum is sometimes slightly carinated near the tip.

I doubt the accuracy of the locality label of the specimen of this species in the Museum of Comparative Zoölogy numbered 197. It was taken from a jar containing *C. Diogenes* from Lawn Ridge, Ill. No other specimens have been reported from the West.

The specimen in the Museum of Comparative Zoölogy (No. 3337) labelled Rocky River, Olmsted, Ohio, determined as *C. troglodytes* by Hagen (p. 43), seems to be *C. Clarkii* (see p. 27).

According to colored drawings of this species made from living specimens by J. Burkhardt at Charleston, in 1853, the body is brownish red, the tubercles on the chelæ bright red, legs red below.

Dr. Le Conte states that in Lower Georgia this species is found in the ricefields, where it makes holes four inches deep, and in ditches (*A. fossarum*).

Specimens from Richmond Co., neighborhood of Augusta, Ga., received recently from Col. Charles C. Jones, Jr. (Cat. No. 3550), are noteworthy in that the male appendages, especially of the second form, approach closely in their form those of *C. Clarkii*. In the shape of the rostrum and other respects these specimens agree with *C. troglodytes*. The telson is trispinose on each side. In the light of these specimens, I am inclined to suspect that further explorations will break down the specific distinctions between *C. troglodytes* and *C. Clarkii*. But my material does not represent a wide enough geographical range to warrant a definite opinion.

6. Cambarus maniculatus.

Astacus maniculatus, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 401, 1855.
Cambarus maniculatus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 52, 1870. (After Le Conte.)
Cambarus maniculatus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 137, 1884. (After Le Conte. No description.)

This species is known only from the description of Le Conte, which is quoted in full on page 52 of Hagen's Monograph. The description was perhaps drawn up from an immature specimen of *C. troglodytes*. The number of hooked thoracic legs in the male is not specified in Le Conte's description, but the species is probably one of the *C. Blandingii* group, since it is placed among the species of that group in Le Conte's list.

7. Cambarus Lecontei.

Plate II. fig. 2.

Cambarus Lecontei, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 47, Pl. I. figs. 15–18, Pl. III. fig. 145, 1870.
Cambarus Lecontei, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 137, 1884.

Known Localities. — Alabama: Mobile. Georgia: Athens.

Resembles *C. Blandingii* and *C. fallax*, but is easily distinguished from these by the shortness of the portion of the carapace behind the cervical groove, the greater length of the acumen of the rostrum, antennal scale, and chelæ, and the shape of the male sexual appendages. The areola is somewhat wider. The rostrum is deeply excavated above, the sides converging but slightly up to the lateral teeth, which are separated by more than one half of the width of the base of the rostrum. The proximal segment of the telson is armed on each side of its distal margin with three or four teeth.

The proportions may be seen from the following measurements of a male, form I.: Length of body, 86 mm.; of carapace, 43 mm.; of abdomen, 48 mm. From tip of rostrum to cervical groove, 31 mm.; from cervical groove to posterior border of carapace, 12 mm. Length of rostrum, 14 mm.; of acumen, 5 mm. Breadth of rostrum at base, 7 mm.; at lateral spines, 4 mm. Breadth of areola, $2\frac{1}{3}$ mm. Length of chela, 40 mm.; breadth, 8 mm.

Smaller specimens are more characteristic on account of a greater proportional breadth of the areola and shortness of posterior portion of the carapace. In a male, form II., 65 mm. in length, the length of the carapace from the tip of rostrum to cervical groove is 24 mm.; from cervical groove to posterior border of carapace, 8.5 mm. Breadth of areola, 2 mm.

The types of *C. Lecontei* came from Mobile, Ala. The specimens from other localities assigned to this species by Hagen, on page 48 of his Monograph, certainly do not belong here. The specimens from Beaufort, N. C., and Root Pond, Miss., are *C. Blandingii*. The female from Milledgeville, Ga. (No. 246) ill agrees with the types, on account of the shortness of the acumen of the rostrum (the rostrum being like that of *C. Blandingii*), the short and broad antennal scales, breadth of the hand, etc. Of the three young specimens, one is *C. spiculifer*, the others are too small to be determined with any certainty. The three specimens from Pensacola, Fla. (No. 249) are young (one female, two males), and resemble *C. Lecontei* only in the shortness of the posterior portion of the carapace and the width of the areola; in other respects, they are like the smooth form of *C. Blandingii*, var. *acuta*. There is no lateral spine on the carapace, and the telson is bispinose.

Besides the Mobile types, I have found but one other specimen of this species in the Museum, a young female in a jar with *C. spiculifer* (Cat. No. 172), from Athens, Ga.

8. Cambarus angustatus.

Astacus angustatus, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 401, 1855.
Cambarus angustatus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 50, Pl. I. figs. 65–67, Pl. III. fig. 146, 1870.
Cambarus angustatus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 137, 1884.

Locality. — Lower Georgia.

This species is known only through a dry type specimen in the Museum of the Academy of Natural Sciences of Philadelphia. Le Conte's description of the species is as follows: —

"*A. angustatus.* — Rostrum concavum, valde acuminatum, utrinque versus apicem fortiter et acute unidenticulatum. Lamina antennalis pedunculum antennalem æquans. Cephalothorax punctatus, parcius ad latera, adeo ut vix paucis punctis notatur, linea ordinaria apice spina armata. Thorax totus punctatus, parcius ad latera, tuberculis vel granulis nullis. Areola suturalis lata. Dorsum sicut in prioribus [i. e. glabrum seriebus parvis punctorum transversalium]. Chela parva, angusta, subcylindrica, punctata, sine tuberculis aut granulis, excepto margine interiore qui paucis denticulus inconspicuis instructus est, digiti recti punctati carinati. Carpus glaber, punctis tribus vel quatuor. Brachium glabrum, spinulis paucis latere superiore: inferiore seriebus duabus spinarum, quarum duæ anteriores majores et longiores. Caudæ lamella intermedia utrinque trispinosa.

"Long. 1.95. Cephalothorax .6. Thorax .25. Abdomen .8. Cauda .3. Antenna .9. Chela .6, latitud. .2, forceps .3.

"Habitat in Georgia inferiore, in aquæ puræ rivulos qui inter colliculos arenosos (*sand-hills*) currunt."

The Philadelphia type agrees well with Le Conte's description. The chela, however, under close inspection, is seen to be covered with obsolescent, ciliate, squamous tubercles, and the areola is moderate rather than wide. The fingers are ciliated along their inner margins. There is a single lateral spine on each side of the thorax, three spines on the right side of the telson, four on the left side. Carpus with two prominent spines on the inside, and one below, near the exterior articulation of the hand. The sides of the rostrum converge but little from the base to the lateral spines. The acumen is long. The sexual appendages are figured by Hagen. The measurements of this specimen (a male, form I.) are these : —

Length, 47 mm. Carapax, 22 mm. Abdomen, 25 mm. From tip of rostrum to cervical groove, 16 mm. From cervical groove to posterior border of carapace, 6 mm. Length of rostrum, 8 mm. ; acumen, 3 mm. Width of rostrum at base, 3 mm. ; between lateral spines, 2 mm. Width of areola, 1.5 mm. Length of chela, 15 mm. ; breadth of do., 4 mm.

It resembles *C. Lecontei* in general appearance, the shape of hand, and number of lateral thoracic and telson spines. The first pair of abdominal legs are different, resembling those of *C. spiculifer*, but different from either. The sides of the rostrum are more nearly parallel than in *C. Lecontei*, in this respect resembling *C. versutus*. It seems to be a very much smaller species than its near allies.

9. Cambarus pubescens.

Plate I. fig. 3, Plate VIII. figs. 1 a, 1 a'.

Cambarus pubescens, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 109, 1884.

Male, form II. — Rostrum long, triangular, sides subparallel at the base, then converging towards the lateral spines, which are evident ; slightly depressed above at the base, subplane, with raised margins ; ciliated, especially on the acumen ; acumen long, pointed. Post-orbital ridges with anterior spines. Carapace cylindrical, fore border angulated behind the antennæ, punctate above, slightly granulated on the sides, with one lateral spine on each side. Cervical groove ciliated. Cardiac region short (much less than

one third as long as the anterior part of the carapace). Areola broad. Sternum covered with a dense growth of coarse setæ. Abdomen longer than the cephalothorax. Proximal segment of telson armed on each side with four spines. Anterior process of epistoma broad triangular with ciliated margin. Basal segment of antennule with a sharp spine below, near the inner margin of the middle of its length. Antennæ shorter than the body. Second and third segments with acute external spine; scale a little longer than peduncle of antennæ and rostrum, moderately broad, broadest below the middle. Third maxillipeds hairy within and below. Chela moderately broad, covered with inconspicuous ciliate squamous tubercles, internal margin nearly straight. Fingers as long as the hand, densely ciliated. Carpus tuberculate, a prominent spine within, and one near each point of articulation with the chela. Meros smooth outside and inside, tuberculate and spinous above, biserially spinous and ciliate beneath. Third and fourth pairs of legs toothed on the third segment. Fifth pair of legs with a hook on the basal segment. Anterior abdominal appendages of moderate length, articulated at the base, internal part with an articulated spine obliquely placed, external part terminating in a rounded head with two short, blunt teeth.

Female. — Differs from the male in its shorter and smaller claws. The sternum is densely ciliated, as in the male. The annulus ventralis conical with sigmoid longitudinal fissure; movable.

Length, 54 mm. Carapace, 26 mm. Abdomen, 29 mm. Distance from tip of rostrum to cervical groove, 19 mm.; from cervical groove to posterior border of carapace, 7 mm. Width of areola, 3 mm. Length of chela, 15.5 mm.; breadth, 4 mm. (In the female, which is 59 mm. long, the chela is 12 mm. long by 4 mm. wide.)

Two specimens, one male of the second form and one female, in the U. S. National Museum (No. 3181), collected by A. Graves in McBean Creek, a tributary of the Savannah River a little south of Augusta, Georgia, are the types of this species. There are two young female specimens from the same region, Richmond Co., in the Museum of Comparative Zoölogy.

Differs from *C. Lecontei* and *C. angustatus* by its broader areola, subplane rostrum, and the pubescence of rostrum and cervical groove. The male appendages also differ, as shown in the description and figures.

10. Cambarus spiculifer.

Plate II. fig. 5.

Astacus spiculifer, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 401, 1855.
Cambarus spiculifer, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 48, Pl. I. figs. 59–62, Pl. III. fig. 147, 1870.
Cambarus spiculifer, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 138, 1884.

Known Localities.— Upper Georgia: Oconee River at Athens and Milledgeville; Ocmulgee River in the neighborhood of Atlanta (Coll. Butler Univ., from D. S. Jordan); Chattahoochee River at Roswell, Cobb Co., and near Gainesville; Etowah River (Coll. Butler Univ., from D. S. Jordan).

There is a male type, form I., in the Museum of Comparative Zoölogy, and one in the Academy of Natural Sciences of Philadelphia.

In none of the specimens seen by me are there three spines on each side of the basal segment of the telson, as is said by Hagen to be sometimes the case (p. 49), nor have I seen an individual with but one lateral thoracic spine (Hagen, p. 50). I think these statements are based upon erroneous determinations, for in the jarful of specimens from Athens, Ga., labelled *Cambarus spiculifer* by Hagen, I find the young of *C. Lecontei*, which has a trispinous telson and one lateral thoracic spine.

Measurements of a male, form II.— Length, 71.5 mm. Carapace, 34.5 mm. Abdomen, 37.5 mm. From tip of rostrum to cervical groove, 25.5 mm.; from cervical groove to posterior margin of carapace, 9 mm. Length of rostrum, 11.25 mm.; breadth of rostrum at base, 5.5 mm.; between lateral spines, 2.75 mm. Length of chela, 29 mm.; breadth of do., 11 mm. Width of areola, 3.5 mm. The largest specimen seen by me is 97 mm. long, male form II.

Cambarus spiculifer has been found as yet only in Upper Georgia, in the Altamaha and Chattahoochee River basins.

C. Lecontei, *C. angustatus*, *C. pubescens*, *C. spiculifer*, and *C. versutus* are distinguished from the other species of Group I. by the shortness of the cardiac region of the carapace. *C. Lecontei*, *C. angustatus*, and *C. pubescens* have one lateral thoracic spine on each side; *C. spiculifer* and *C. versutus* have two. *C. Lecontei* and *C. angustatus* have subcylindrical hands, areola of moderate width, rostrum smooth and hollowed out above; *C. pubescens* has broader hands and areola, rostrum pubescent and subplane above. In *C. angustatus* the sides of the rostrum are subparallel; in *C. Lecontei* the rostrum is more tapering. In both *C. spiculifer* and *C. versutus* the areola is

wide and the hands broad; *C. versutus* has the hand covered with small, close-set, squamous tubercles, the sides of the rostrum are subparallel, and the telson commonly tri- or quadrispinose on each side; in *C. spiculifer* the hands bear large tubercles much less closely set than in *C. versutus*, the rostrum tapers more between the base and the lateral spines, and the telson is bispinose on each side. Each of these five species has characteristic male appendages, figured by Hagen and on Plate VIII. of this Revision.

11. Cambarus versutus.

Cambarus versutus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 51, Pl. I. figs. 55–58, Pl. III. fig. 150, 1870.
Cambarus versutus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 138, 1884.

Known Localities. — Alabama: neighborhood of Mobile. Florida: Cape Barrancas [Pensacola Bay ?].

Cambarus versutus resembles *C. spiculifer* in the shortness of the carapace behind the cervical groove, the wide areola, and the two spines on each side of the carapace. In addition to the difference in the male appendages (see Hagen's figures), the chelæ are covered with small, closely-set squamous tubercles, while in *C. spiculifer* the chelæ have fewer and larger tubercles. In *C. versutus* the hand is sulcated below, along the inner border, and the areola is a little wider. The telson is tri- or quadrispinose in *C. versutus*, bispinose in *C. spiculifer*. The sides of the rostrum converge less between the base and the lateral spines in *C. versutus*.

Measurements of a male, form I. — Length, 73.5 mm. Carapace, 35 mm. Abdomen, 38.5 mm. From tip of rostrum to cervical groove, 26 mm.; from cervical groove to posterior border of carapace, 8.5 mm. Length of rostrum, 12 mm.; acumen, 5 mm. Breadth of rostrum at base, 5.5 mm.; between lateral spines, 4 mm. Length of chelæ, 33 mm.; breadth of do., 11 mm. Width of areola, 4 mm.

Three small dry specimens, two males and one female, from Cape Barrancas, Fla., differ from the Alabama specimens in that the rostrum tapers a little more and is lightly carinated above in the middle third of the median line. Although none of the specimens are over 40 mm. in length, the males are of the first form, with well-developed hooks on the third and fourth pairs of legs. The male appendages agree with those of *C. versutus*. The telson is tri- or quadrispinose, and the hand is sulcated below, along the inner margin, as in *C. versutus*.

12. Cambarus Alleni.

Plate I. fig. 1, Plate VIII. figs. 2, 2.

Cambarus Alleni, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 110, 1884.

Male, form I. — Rostrum broad, triangular, somewhat deflexed, smooth, excavated above, margins raised into sharp crests and gradually converging to near the tip, where they suddenly come together to form the short, sharp acumen; no lateral spines. Post-orbital ridges without spines. Carapace cylindrical, somewhat compressed laterally, fore border angulated behind the antennæ, punctate above, granulated on the sides. Cervical groove deeply sulcated, without lateral spines. Cardiac region more than one third as long as the distance from the tip of rostrum to hind border of carapace. Areola narrow. Abdomen broad, longer than cephalothorax. Angles of pleura rounded. Three or four spines on each side of posterior border of basal segment of the telson. Terminal segment of telson shorter than basal part, one third broader than long, hind margin concave. Anterior process of epistoma subquadrangular. Basal segment of antennules with a sharp spine below, near the inner margin, half-way towards the end of the segment. Antennæ shorter than the body, second and third segments with an external sharp tooth. Antennal scale equal to peduncle, slightly surpassing the rostrum, broad, broadest at the middle, rounded at apex, terminating in a short spine, external margin inflated. Third maxillipeds hairy within and below. Chelipeds slender, chela long, subcylindrical, squamoso-tuberculate, tubercles ciliate anteriorly, internal border straight, serrate. Fingers as long as the hand, with alternate longitudinal ribs and lines of ciliate impressed dots. Opposed margins of fingers straight, unidentate. Carpus squamoso-tuberculate within, obsoletely so without, with one prominent spine on inner border. Meros punctate outside, ciliato-tuberculate within and on upper margin, which has two ante-apical spines obliquely placed; two rows of spines beneath. Third and fourth pairs of legs hooked on third segments, hooks of fourth pair bituberculate. Fifth pair of legs with a flattened laminate tubercle on basal joint. Anterior abdominal appendages of moderate length, bifid at apex, outer part forming a broad flattened plate whose anterior margin is furnished with hairs and one strong seta, the posterior margin of the plate produced anteriorly into a blunt tooth-like process. Inner part bearded within, and produced into a long erect spine, which much exceeds in length the outer part of the appendage.

Length, 62 mm. Rostrum, 6 mm. Carapace, 30 mm. From tip of rostrum to cervical groove, 19.5 mm.; from cervical groove to posterior border of carapace, 10.5 mm. Abdomen, 32 mm. Width of areola, 7 mm. Antennæ, 47 mm. Chelipeds, 49 mm. Chela, 23 mm. Width of chela, 6 mm.

St. John's River, Hawkinsville, Orange Co., Fla.: J. A. Allen.

A well-marked species with toothless excavated rostrum (younger specimens probably have marginal rostral teeth), narrow areola, long, subcylindrical chelipeds covered with ciliated squamous tubercles. The first abdominal legs are not jointed, the hooks on the third and fourth pairs of thoracic legs are large and well finished, so that I consider the single specimen examined to be the first form.

In the collection of the Academy of Natural Sciences of Philadelphia is a specimen from Hernando Co., Fla., Jos. W. Wilcox, which is probably the second form of the male of this species. The sexual appendages are not articulated at the base. The hooks on the third and fourth pairs of legs are small, tooth-like processes merely. Besides the differences in these hooks and in the sexual appendages, the following may be pointed out: the rostrum has small lateral teeth near the tip, the post-orbital ridges have a sharp spine at their anterior end, the basal segment of the fifth pair of legs is armed with a sharp hooked tooth in place of a flattened tubercle, and the hind segment of the telson is longer in proportion to its width.

13. Cambarus penicillatus.

Astacus penicillatus, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 401, 1855.
Cambarus penicillatus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 53, Pl. I. figs. 93, 94, [95, 96?], Pl. III. fig. 149, 1870.
Cambarus penicillatus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 138, 1884.

Known Localities.—Georgia. Eastern Mississippi [?]. Charleston, S. C. [?].

None of Le Conte's types of this species are known. Of the specimens in the Museum of Comparative Zoölogy referred to this species by Dr. Hagen, a small male of the first form, from Georgia (No. 279), agrees well with Le Conte's description. It has a small branchiostegian spine, overlooked in Hagen's description. The rostrum has no trace of ante-apical spines; the antennal scale is very broad, attaining its greatest breadth in the middle, then narrowing but little until reaching the level of the apical spine. It is a little shorter than the peduncle of the second antennæ, and equal to the rostrum in length. The male appendages are represented on Plate I.

of Hagen's Monograph, figs. 93, 94. This is doubtless Le Conte's species. It is peculiar in having tufts of long hair-like setæ on the inner margin of the hand. The only other species known to have these hair-like growths is *Astacus Gambelii*, from the Western United States, which has the pilosity on the outer as well as the inner margin of the hand.

Length, 42 mm. Carapace, 21 mm. Abdomen, 22 mm. From tip of rostrum to cervical groove, 14 mm. Cardiac region, 7 mm. Width of areola, 1 mm. Length of chela, 14 mm.; breadth of do., 5 mm.

Of the other specimens referred to *C. penicillatus*, two young females from Charleston, S. C. (Cat. No. 254) are surely *C. troglodytes*. Two other females and two males, form II., also from Charleston (Cat. No. 250), may be the female and second form of the male of *C. penicillatus*, as claimed by Hagen, but I suspect that they belong to another species. The form of the first pair of abdominal appendages of the male (Hagen, Pl. I. figs. 95, 96) is not what one would expect in the second form of *C. penicillatus*. The antennal scale is narrower, longer, diminishing more rapidly in width beyond the middle. The lack of beard on the hands, a more gradually tapering rostrum with longer acumen, and the trispinous basal segment of the telson also serve to distinguish these specimens from the first form male from Georgia.

In the collection of Butler University, Irvington, Ind., is a male, form II., collected in Eastern Mississippi by O. P. Hay, which closely resembles the specimen of *C. penicillatus* from Georgia, excepting in the following particulars. The base of the rostrum is more clearly foveolate. The areola is only one half the width of that of *C. penicillatus*, being reduced to such an extent as to admit but one line of impressed dots within its area, while in the Georgian specimen there are two or three parallel longitudinal rows in the narrowest part of the areola. The fore border of the carapace is not angulated behind the antennæ, as in the specimens from Georgia and Charleston. The setæ that grow from the squamous tubercles on the inner edge of the hand are longer than on the other parts, but are not drawn out into pencils, as in the first form from Georgia.

The first pair of abdominal appendages are articulated at the base, recurved at their distal end, though not so strongly as in the first form from Georgia; internal part with a short apical tooth directed obliquely outwards, external part with two stout apical teeth. The short apical tooth of the internal part of the appendage gives it a very different appearance from the second form males from Charleston, described above, and referred to *C. peni-*

cillatus by Hagen, and the two can hardly belong to the same species. The teeth at the tip of the external part are also shorter and blunter in the Mississippi specimen than in those from Charleston. The hooks on the third and fourth pairs of thoracic legs are very small, — mere tooth-like processes. The antennal scale is broad at the tip, as in the Georgia specimen.

Measurements. — Length, 50 mm. Carapace, 25 mm. Abdomen, 26 mm. Rostrum, 5 mm. From tip of rostrum to cervical groove, 16.5 mm. Cardiac region, 8.5 mm. Width of areola, .5 mm. Length of chela, 14 mm.; breadth of chela, 5 mm.

This specimen, as well as those from Charleston, may belong to different species from *C. penicillatus*, but my material is not sufficient to warrant the establishment of new species.

Le Conte does not specify from what part of Georgia his specimens came, nor is the locality of the Georgia specimens in the Museum of Comparative Zoölogy any more precisely indicated.

14. Cambarus Wiegmanni.

Astacus (*Cambarus*) *Wiegmanni*, Erichson, Arch. f. Naturgesch., XII. Jahrg., I. 99, 1846.
? *Cambarus Wiegmanni*, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 54, Pl. III. fig. 151, 1870.
Cambarus Wiegmanni, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 138, 1884.

Four species of Cambarus have been described from Mexico; viz. *C. Wiegmanni* Erichs., *C. Mexicanus* Erichs., *C. Azteeus* Saussure, and *C. Montezumæ* Saussure. *C. Wiegmanni* has hooks near the base of the third and fourth pairs of legs of male, tuberculated chelæ, carpus dentated on the inner border. *C. Mexicanus* has only the third pair of legs of the male hooked, chelæ granulated, carpus unarmed. *C. Azteeus* also has the third pair of legs hooked in the male, chelæ granulated, more compressed than in *C. Mexicanus*, carpus armed with some spines within and below. It is doubtful whether this be specifically distinct from *C. Mexicanus*. In *C. Montezumæ* the second and third pair of legs of the male are hooked, the carpus and chelæ smooth. To the list of Mexican Cambari is to be added *C. immunis*, collected at Orizaba by Prof. Sumichrast. An undescribed Parastacine occurs at Colima, on the west coast.

The types of Erichson's two Mexican species of Cambarus, *C. Wiegmanni* and *C. Mexicanus*, could not be found in the Berlin Museum, either by Hagen, who examined the collection in September, 1870, or by Von Martens (Arch. Naturgesch., 1872, p. 131). *C. Wiegmanni* alone of the known Mexican spe-

cies belongs to the *C. Blandingii* group, with hooks on the third and fourth pairs of legs in the male. The female specimen in the Acad. Nat. Sci. Phila. (No. 170, Mr. Pease), fully described by Hagen, is probably correctly referred to this species by him, although in the absence of male specimens there is some uncertainty. It would seem to belong here rather than to *C. Mexicanus*, on account of the tuberculous chelæ and the dentiform tubercles on the inner margin of the carpus.

I have seen but one specimen of *C. Mexicanus*, a male. In this the chelæ are more cylindrical, and are covered with smaller, more closely set, granular tubercles. In the collection of Acad. Nat. Sci. Phila. I find another alcoholic female from Jalapa, Mexico, which agrees well with Mr. Pease's specimen. A mutilated female in the U. S. Nat. Mus. (No. 3288, Prof. Sumichrast), from the Isthmus of Tehuantepec, seems also to belong here.

C. Wiegmanni differs from *C. penicillatus* in the strongly tuberculated chelæ, rostrum narrowing more suddenly before the acumen, and broader areola. Erichson's description is appended. The form of the male appendages is not noticed.

"*A.* (*Cambarus*) *Wiegmanni:* Chelis tuberculatis, digitis æqualibus, carpis intus dentatis, rostro lato, lanceolato.

"Panzerschild punktirt, die Längsleisten an der Schnabelwurzel kurz, etwa bis zur Mitte des dritten Gliedes der äusseren Fühler reichend, der Schnabel breit, lanzettförmig zugespitzt, oben flach ausgehöhlt, mit aufgeworfenem scharfen Rande. Die Fühlerblätter sehr breit, der Aussenrand etwas verdickt, mit überragender Spitze. Die Scheerenbeine ziemlich kurz, die Scheeren länglich, ziemlich schmal, oben und unten gewölbt, mit kleinen Höckerchen etwas weitläufig besetzt, am Innenrande die Höcker dichter und spitzer; die Finger kräftig, gefurcht, in den Furchen punktirt; das Glied vor der Scheere am Innenrande mit einigen Zähnen besetzt. Der Schwanz etwas zusammengedrückt, schmäler als das Panzerschild, nach hinten allmählich etwas verschmälert.

"Das zweite Glied am dritten und am vierten Beinpaar beim Männchen mit einem hakenförmigen Fortsatz.

"Länge des Korpers von der Schnabelspitze bis zum Ende der Schwanzflosse 2″, des Schnabels $2\frac{1}{2}$‴, des Scheerenbeins 1″ 4‴, der Scheere 8‴, Breite derselben fast 3‴, grösste Breite des Panzerschildes 6‴, Hohe desselben ebenfalls 6‴.

"In Mexiko. Von Deppe gesammelt."

15. Cambarus pellucidus.

Astacus pellucidus, Tellkampf, Arch. Anat., Physiol. u. wissensch. Med., 1844, p. 383.
Astacus (Cambarus) pellucidus, Erichson, Arch. Naturgesch., XII. Jahrg., I. 95, 1846.
Astacus pellucidus, Gibbes, Proc. Amer. Assoc. Adv. Sci., 3d Meeting, p. 195, 1850. (No description.)
Cambarus pellucidus, Girard, Proc. Acad. Nat. Sci. Phila., VI. 87, 1852. (No description.)
Cambarus pellucidus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 55, Pl. I. figs. 68–71, Pl. III. fig. 148, Pl. VI., 1870. — Amer. Naturalist, VI. 494, 1872.
Cambarus pellucidus, Packard, Amer. Naturalist, V. 750, fig. 131 (after Hagen), 1871. — Fifth Ann. Rep. Trustees Peabody Acad. Sci. for the Year 1872, p. 94, 1873.
Orconectes pellucidus, Cope, Amer. Naturalist, VI. 410, 419, 1872. — Third and Fourth Ann. Rep. Geolog. Surv. Indiana, pp. 162, 173, 1872.
Orconectes inermis, Cope, Amer. Naturalist, VI. 410, 419, 1872. — Third and Fourth Ann. Rep. Geolog. Surv. Indiana, pp. 162, 173, 1872.
Cambarus pellucidus, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 639, 1874. (No description.)
Cambarus pellucidus, Putnam, Proc. Boston Soc. Nat. Hist., XVII. 222, XVIII. 16, 1875. (Habits.)
Cambarus pellucidus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 139, 1884.

Known Localities. — Kentucky: Mammoth Cave and other caves in Edmonson Co. Indiana: Wyandotte Cave, Crawford Co.; cave in Bradford, Harrison Co.

The earliest notice of the blind crayfish of the Mammoth Cave occurs in the Proceedings of the Academy of Natural Sciences of Philadelphia, Vol. I. p. 175. In the record of the meeting of the Academy on May 24, 1842, the donation of a specimen is thus acknowledged: "A white eyeless crayfish (*Astacus Bartoni*?) . . . . from the Mammoth Cave, Kentucky, about $2\frac{1}{2}$ miles from the entrance. Presented by W. T. Craige, M. D."

From a "Notice of the Blind Fish, Crayfish, and Insects from the Mammoth Cave, Kentucky," communicated by William Thompson to the Annals and Magazine of Natural History (Vol. XIII. p. 111, February, 1844), I quote the following: —

"At a meeting of the Belfast Natural History and Philosophical Society, Jan. 17, 1844, Mr. Thompson, the President, called attention to specimens of the Blind Fish, Crayfish, and Locusts from the great Mammoth Cave in Kentucky, procured in the month of May last, specially for the Society, by the kind attention of our townsman, Gordon A. Thomson, Esq., on his visit to the cave. They are perhaps the first examples of their respective species brought thence to Europe.

"The cave itself is popularly known from having been described in 'Chambers's Edinburgh Journal' for 1838, Vol. VI. p. 234; and more recently, at least in this town, from a letter by the Rev. Wm. Murphy, St. Mary's

College, Kentucky, published in the 'Belfast Commercial Chronicle' of Jan. 1, 1844, where it occupies two columns, but the source whence it was obtained is not acknowledged. . . . . The crayfish and 'crickets' are stated in the letter already noticed [the Rev. Wm. Murphy's ?] to be blind, but this is erroneous. Both species have eyes. Our specimen of the crayfish wants both the claws, but is otherwise perfect, and agrees with the description of the *Astacus Bartoni* Fabr., given in Milne Edwards's 'Histoire des Crustacés,' Vol. II. p. 331. The length there attributed to the species is 3 inches; the specimen before us is $2\frac{1}{4}$ inches in length from the point of the rostrum to the extremity of the caudal plates."

The description of *Astacus Bartonii* by Milne Edwards, here referred to, is in reality a description of *Astacus affinis* Say; but as *C. Bartonii* is the only eyed crayfish known to inhabit the Mammoth Cave, it was probably the species in Thompson's hands. Tellkampf's type (a male, form I.) was more fully described by Erichson, and was seen by Hagen in the Berlin Museum in September, 1870.

The presence in the Mammoth Cave of a crayfish with well-developed eyes, together with the blind species, was noticed by Prof. B. Silliman, Jr., in 1850. In a letter to Professor Guyot, dated Louisville, Nov. 8, 1850, printed in the American Journal of Science and Arts, 2d Ser., Vol. XI., May, 1851, he says (p. 336): —

"The crawfish, or small crustacea inhabiting the rivers with the fish, are also eyeless and uncolored, but the larger-eyed and colored crawfish, which are abundant without the cave, are also common at some seasons in the subterranean rivers. . . . . Among the collections are some of the larger-eyed crawfish which were caught by us in the cave."

I have now before me specimens of *C. pellucidus* and *C. Bartonii* from the Peabody Museum of Yale College (Nos. 1814, 1815), collected by Professor Silliman in the Mammoth Cave. More recently, *C. Bartonii* has been frequently captured there.

The association of *C. pellucidus* and *C. Bartonii* in the Mammoth Cave, and the fact that cave specimens of the latter are often very light colored, led Professor N. S. Shaler* to conclude that the two species were connected by transitional forms, and that the blind form was derived from the present outside fauna of the region. He even goes so far as to suppose that the blind form, *C. pellucidus*, is continually reinforced by interbreeding with the

* Mem. Boston Soc. Nat. Hist., II. 362, 363, 1875.

eyed form derived from without the cave! But as we have seen (see p. 18), *C. pellucidus* is a very aberrant species, with no very closely related form outside the cave. The simple form of the male appendages, and the combination of characters belonging to different groups,* seen in *C. pellucidus*, indicate, to my mind, that it is a very ancient form, which has been preserved in the seclusion of the cave, while its nearest kin succumbed in the sharper struggle incident to life outside, or were replaced by modified descendants evolved to meet the changeable conditions which obtain without the caverns. This view is rendered more probable when one remembers that the same form, *C. pellucidus*, occurs in the Wyandotte Cave on the other side of that ancient river, the Ohio. The transportation of an eyeless cave species from the Kentucky caverns to those of Indiana seems out of the question, and one is driven to the conclusion that the subterranean waters of both localities derived this eyeless species from a similar form with well-developed eyes, that peopled the streams throughout this region at a remote period. Further, if we trust the statements of Gustav Joseph (see p. 45), a Cambarus is found in the caves of Carniola in Southern Austria very closely related to *C. pellucidus*, while all the European crayfishes else belong to another genus, Astacus. That the similarity of conditions affecting cavern life in all parts of the world is sufficient to bring about the close agreement between the crayfishes of the caves of Carniola and Kentucky, when the forms outside the caves belong to different genera in the two localities, seems highly improbable. The genus Cambarus in North America has not originated under the influences of subterranean life, but is the ordinary form of crayfish throughout the whole of the eastern and central portions of the continent. If the cave species of Carniola were derived from the present outside fauna of Europe, we should have a blind Astacus instead of a blind Cambarus. I am rather inclined to accept the Carniola cave species as a witness to the former existence of the genus Cambarus in the rivers of Europe (see p. 176).

C. pellucidus is subject to considerable variation. In some specimens the rostrum is shorter than in typical specimens, and contracts more from the base to the lateral teeth, which are much less prominent. The spines of the postorbital ridge and sides of the carapace are slightly developed. This is the form described as a new species, *Orconectes inermis*, from Wyandotte Cave, Indiana, by Prof. Cope, in 1872. I owe to Prof. A. S. Packard

* With the essential characters of Group I. are found the general form of body of the species belonging to Group III. and the rostrum of Group IV. The antennal scale dilated near the tip is characteristic of Groups III. and IV., rather than of Group I.

an opportunity to examine Cope's type. It is a male, form II., with the first pair of abdominal appendages not articulated, a condition often found in the second form males of this species. After an examination of this specimen, I can indorse the opinion of Hagen (Amer. Nat., Aug., 1872) and Packard (Fifth Ann. Rep. Peabody Acad. Sci., for 1872), expressed before seeing the specimen, that the variation is not of specific value. All the specimens which I have seen from the Indiana caves, amounting to six in number, belong to this form. But the same form also comes from the Mammoth and neighboring caves in Kentucky. In a gigantic female in the Museum of Comparative Zoölogy (No. 3417, collected in Mammoth Cave by F. W. Putnam), the peculiarities of Cope's form are intensified. The point of the rostrum does not reach the distal end of the peduncle of the antennule, and hardly attains the proximal end of the distal segment of the peduncle of the antenna.* The lateral rostral spines are reduced to salient angles. The post-orbital ridges are destitute of spines, as in *C. Bartonii*. The antennal scales reach but to the proximal end of the terminal segment of the peduncle of the antenna. The lateral spinules of the carapace are represented by granular tubercles. The spines of the meros of the cheliped are short and tooth-like; those on the upper surface are blunt, those beneath are irregularly disposed, without the clear biserial order seen in the typical form, and also in Cope's type of *O. inermis*. The hands are broad, flattened, and tuberculate.

In this specimen, moreover, the anterior process of the epistoma is truncated in front. The dimensions are subjoined. Length of body, 93 mm.; of carapace, 46 mm.; of rostrum (from level of post-orbital spines to tip), 9 mm.; of abdomen, 49 mm.; from tip of rostrum to cervical groove, 26 mm.; from cervical groove to posterior margin of carapace, 20 mm. Length of cheliped, 84 mm.; of chela, 43 mm.; of antenna, 86 mm.; of antennal scale, 8 mm.

The other blind *Cambarus* from the United States (*C. hamulatus* from Nickajack Cave, Tenn.) resembles *C. pellucidus* superficially, but belongs to Group III., with hooks only on the third pair of legs in the male. The first pair of abdominal appendages are very different from those of *C. pellucidus*, being formed after the pattern of those organs in *C. Bartonii*. The annulus ventralis of the female is also different.

A small specimen of *C. pellucidus* was found in a jar containing *C. Putnami* from Green River, near the Mammoth Cave, collected by Mr. F. W. Putnam.

* In the typical form of *C. pellucidus* the rostrum equals or exceeds in length the peduncle of the antenna.

So it would seem that the blind species sometimes finds its way out from the cave.

The blind fishes of the Mammoth Cave are compensated for the loss of sight by the development of special tactile papillæ. Among the Crustacea the eyeless *Gammarus puteanus* and *Asellus cavaticus* are more richly furnished with olfactory setæ than are their relatives that enjoy the sense of sight. In the Astacidæ the setæ to which Leydig has ascribed an olfactory function are borne by the outer flagellum of the antennules. Leydig* has described their arrangement in *C. pellucidus*. The outer flagellum is composed of about thirty-six segments. The olfactory setæ are situate for the most part on the distal half of the flagellum, beginning with the fifteenth segment, the number of setæ on each segment decreasing toward either extremity of the olfactory portion of the flagellum. Leydig was unable to compare *C. pellucidus* with any of the species of Cambarus possessed of eyes, but he observed that the antennulary flagella of *Astacus fluviatilis* were shorter and contained fewer segments than in *C. pellucidus*. This, however, is a generic distinction, and cannot be brought into relation with the absence of visual organs in the cave species.

Professor R. Ramsay Wright† has followed up Leydig's suggestion by a comparison of the so-called olfactory organs of *C. pellucidus* with those of the eyed *C. propinquus*. He finds that the external flagellum of the antennule of the latter species is composed of eighteen or nineteen segments, the distal nine of which alone bear olfactory setæ. He therefore concludes that *C. pellucidus*, like the blind Gammarus and Asellus, has acquired a more complete olfactory apparatus in compensation for the loss of sight.

I have examined several specimens of *C. propinquus* with reference to this point, and find that the number of segments in the external flagellum of the antennule may be as high as thirty-five, fifteen or sixteen of which may carry olfactory organs. In *C. affinis* I have counted as many as thirty-three segments in the flagellum, nineteen with olfactory setæ. A moderate-sized *C. Blandingii* from New Jersey reveals about fifty segments, twenty-nine of them provided with olfactory setæ. It thus appears that Professor Wright's conclusion, that the number of antennulary segments and olfactory organs is increased in the blind species, is not supported by the facts. It is noteworthy, however, that the olfactory setæ of *C. pellucidus* are longer

* Untersuchungen zur Anatomie und Histologie der Thiere, p. 38.
† American Naturalist, Vol. XVIII. p. 272, March, 1884.

than in most species of Cambarus. In a specimen of *C. hamulatus*, the other blind cave species, there are thirty segments in the outer flagellum of the antennule, and the olfactory setæ are long, as in *C. pellucidus*.

Cambarus typhlobius.

Cambarus Stygius, Joseph, Berliner Entomolog. Zeitschr., XXVI. 12, April, 1882. (Name preoccupied by Bundy.)

The earliest notice of the existence of a blind crayfish, closely resembling *Cambarus pellucidus*, in the caves of Carniola, is in the 57th Jahresbericht der Schlesischen Gesellschaft für vaterländische Cultur, 1879, p. 202, Breslau, 1880. It is there recorded that Dr. Gustav Joseph "demonstrirte einen neuen, 9 cm. langen, zur Familie der Astaciden gehörigen blinden Grottenkrebs aus Krain, welcher der aus der Mammuthshöhle von Kentucky in Amerika bekannten Art (*Cambarus pellucidus* Tellkampf) sehr nahe steht und deshalb vom Vortragenden *Cambarus typhlobius* n. sp. benannt worden ist."

In a paper published in December, 1881, in the twenty-fifth volume of the Berliner Entomologische Zeitschrift,* the same writer mentions, without describing, the animal, under the names *Cambarus cæcus* n. sp. (p. 237) and *Cambarus Stygius* n. sp. (pp. 241, 249).

In the twenty-sixth volume of the same journal, pp. 12–14, April, 1882,† a fuller account of the animal is given by Dr. Joseph. On account of the importance of the discovery, and the rarity of the Berlin Entomological Journal in America, I transcribe the entire description.

"*Cambarus Stygius*, n. sp.

"Wie *Anophthalmus Tellkampfii* Erichs. aus der Mammuth-Höhle bei Kentucky der nächst Verwandte des Krainer *A. Schmidtii* Sturm, so erscheint *Cambarus Stygius* mit dem amerikanischen *C. pellucidus* Tellkampf aus der genannten Höhle sehr nahe verwandt. In der Sammlung von Ferdinand Schmidt in Ober-Schiska bei Laibach befand sich zur Zeit ein getrockenes Exemplar dieser von mir entdeckten Krebsart, das aus der Grotte von St. Kanzian stammte und mit dem Namen '*Astacus saxatilis*' (?) bezeichnet war. Reste von Scheeren fand ich im Darm eines Olm, der in einer Höhle bei Gabroviza oberhalb Triest gefunden sein soll. Nachträglich wurde mir mitgetheilt dass in der Höhle von Ospo unweit Triest ein grosser, dem Flusskrebs ähnlicher, Krebs vorkommen soll. Die Exploration derselben im September 1881 in Begleitung des Herrn Dr. Graeffe, Inspector der Kais. Königl. Zoolog. Station in Triest, hatte aber ein negatives Resultat. Das Exemplar meiner Sammlung, welches ebenfalls aus dem Reccafluss aus der Grotte von S. Kanzian bei Metaùn unweit Divazza stammt, ist ein geschlechtsreifes Männchen, das an Grösse die amerikanische Art nach der von Packard ('The Mammoth Cave and its Inhabitants'. . . .) veröffentlichten Abbildung kaum übertrifft. Trotz aller Mühe gelang es mir bisher nicht mir ein Exemplar der amerikanischen Art Behufs Vergleichung zu verschaffen. Leider stand mir auch nicht die Abbildung, welche Tellkampf und Hagen

* "Erfahrungen im wissenschaftlichen Sammeln und Beobachten der den Krainer Tropfsteingrotten eigenen Arthropoden von Dr. Med. et Phil. Gustav Joseph, Docenten a. d. Universität Breslau."

† "Systematisches Verzeichniss der in den Tropfsteingrotten von Krain einheimischen Arthropoden nebst Diagnosen der vom Verfasser entdeckten und bisher noch nicht beschriebenen Arten."

von diesem grössten aller Grottenkrebse geben, zu Gebote, wahrend die von Packard publicirte nicht detaillirt genug ist, um bei Vergleichung die nöthige Sicherheit zu gewähren. Von der Spitze des Rostrum frontale bis zur Schwanzflosse misst das (7 Jahr in Spiritus aufbewahrte) Thier 6.5 cm. Die lateralen grossen Fühler sind um $\frac{1}{10}$ langer als bei der amerikanischen Art. Die Basis der innern Fühler ragt weiter als das Rostrum nach vorn, während bei der amerikanischen Art Nichts davon zu sehen ist. Während in der Packard'schen Abbildung die Augäpfel nicht wahrnehmbar sind, erscheinen dieselben bei dem Krainer Exemplar ebenso deutlich wie bei *Troglocaris Schmidtii*, aber statt der Hornhautfacetten besteht das Integument des Augapfels wie des Augenstiels aus undurchsichtiger Chitinhaut. Ebenso fehlen wie bei dem blinden Cariden jegliche lichtbrechende und lichtempfindende Elemente. Der Augapfel ist erfüllt von derber bindegewebiger, mit Fett durchsetzter Masse. Durch den Augenstiel zieht ein bindegewebiger Streif in der Richtung gegen das obere Schlundganglion hin, Befunde, wie ich sie bereits seit länger als einem Jahrzehnt bei *Troglocaris Schmidtii* gefunden und veröffentlicht habe. Indem ich mir die Abbildung und genaue Beschreibung für eine grössere Arbeit über die Gesammtfauna der Krainer Grotten vorbehalte, will ich nur noch folgende, im Vergleich zur wahrscheinlich mangelhaften Packard'schen Abbildung der amerikanischen Art höchst auffallende, Unterscheide hervorheben. Von dem 2. Gliede des 3. Schreitfusses ragt ein hakenförmiger Auswuchs von $\frac{1}{3}$ der Grösse dieses Gliedes schief nach vorn und (proximalwärts) medialwärts; ebenso von entsprechender Stelle am 4. Schreitfuss ein ähnlich gestalteter aber kürzerer und schmächtiger. Das 1. Paar der Schwimmfüsse ist in ähnlicher Weise zu Begattungsorganen umgebildet, wie bei dem Flusskrebs; das 2. Paar ist im Endgliede membranös und tief gespalten."

From this imperfect description it appears that the peduncle of the antennule is longer in proportion to the rostrum than in the typical *C. pellucidus*, and the eye larger. Whether this species conforms to the genus Cambarus in the number and arrangement of the gills, we are not told; but the presence of hooks on the third and fourth pairs of legs seems to indicate a true Cambarus.*

As the name *Cambarus Stygius* was employed by Bundy, in 1876, for an American species, I have adopted the name suggested by Joseph in his first notice of this species.

It is to be lamented that a fuller account of this animal has not been published, on account of its important bearings on the subject of the geographical distribution of these animals. Remarks on the meaning of the presence of this Cambarus in the caves of Carniola, the sole representative of the genus in the Eastern continent, will be found on pp. 42, 176.

Cambarus Stygius.

Cambarus Stygius, Bundy, Bull. Ill. Mus. Nat. Hist., No. I. p. 3, 1876. — Trans. Wis. Acad. Sci., V. 180, 1882. — Geol. Wis., Surv. 1873–1879, I. 402, 1883.
Cambarus Stygius, Forbes, Bull. Ill. Mus. Nat. Hist., No. I. p. 19, 1876. (After Bundy.)

"Rostrum long and pointed, smooth above, foveolate at base, cephalothorax slightly compressed, smooth or slightly punctate above, finely granulate on sides; areola narrow; lateral spine acute; antennal plates wide, truncate, with short apical teeth; epistoma

* I presume that Joseph's statement, that the hooks spring from the second segment of the leg in the Carniola species, is an error, since these processes are always found on the third segment.

rounded in front, twice as wide as long; third maxillipeds hairy on inner and lower aspects; chelæ short, smooth above, serrate on interior margins; fingers short, nearly straight, costate and punctate above, contiguous margins tuberculate, exterior one hairy; third joint of third (and fourth ?) thoracic legs of male hooked. (Of three males sent me by Dr. P. R. Hoy, not one had the fourth thoracic legs remaining.)

"First abdominal of male short, truncate, with three short, obtuse teeth directed outward from the posterior margin at apex. A smooth groove passes up on the outside of the leg between these teeth and the anterior margin.

"Ventral annulus of female flat, transversely elliptical, posterior margin slightly elevated.

"This species is closely related to *C. acutus*, but may be at once separated by the shorter hands — similar to those of *C. propinquus* — and the non-tuberculated annulus of female.

"Found by Dr. P. R. Hoy on the shores of Lake Michigan [at Racine, Wis.], having been washed ashore during a storm." — Bundy, Geol. Wis., Vol. I. p. 402.

Color, "dark cream, darker along the sutures."

This species is known to me only through the descriptions of Bundy. In his earlier description, in the Bulletin of the Illinois Museum of Natural History, he states that the rostrum has "small teeth near apex," and that the carinæ are "parallel, separated from base of rostrum by slight grooves." In this description it is said that the "third and fourth joints of third thoracic legs" are hooked. This is probably a printer's error for the "third joint of third (and fourth ?) thoracic legs of male hooked" of the later description. Misled by this typographical (?) error, Forbes, in his synopsis of the species mentioned in the paper in the Bulletin of the Illinois Museum of Natural History, places this species with *C. gracilis* in the group with hooks only on the third pair of legs. The "outer margin of finger hairy," of Forbes's diagnosis, seems to show a misconception of Bundy's description, which undoubtedly means *inner margin of outer finger hairy.*

GROUP II. (Type C. advena.)

Third segment of third pair of legs of male hooked. First pair of abdominal legs of male similar to those of Group I.

The species of this group seem to form the passage from Group I. to Group III. (*C. Bartonii*). The first pair of abdominal appendages of the male are similar to those of the species in the *C. Blandingii* group, being truncate at the tip, the outer part terminating in one or two short tubercles or teeth, the inner part in a short, erect spine. Only the third pair of legs of the male are hooked. *C. simulans*, *C. Mexicanus*, and *C. Cubensis* resemble in their general form and shape of chela the species included in Group I. The chela and antennal scale of *C. simulans* are much as in *C. Blandingii*, var. *acuta*. In *C. Mexicanus* and *C. Cubensis* the chela is sub-cylindrical and slender, and covered with small ciliated squamous tubercles. *C. advena*,

C. Carolinus, and *C. gracilis* resemble *C. Diogenes* of Group III. in the general form of body, linear areola, small antennal scale, broad chela, etc. The fore border of the carapace is angulated behind the antennæ in *C. simulans*, *C. Mexicanus*, *C. Cubensis*, and *C. gracilis;* not angulated in *C. advena* and *C. Carolinus*. The rostrum is armed with small lateral teeth in *C. Cubensis;* in the other species of this group the rostrum has no lateral teeth.

Of the species belonging to this group, Hagen knew only *C. advena* and *C. Carolinus*. These were placed by him, as aberrant forms, in Group III. (*C. Bartonii*).

- Rostrum with small lateral teeth, areola broad. *C. Cubensis.*
- Rostrum without lateral teeth.
  - Areola of moderate width. Chelæ subcylindrical. *C. Mexicanus.*
  - Areola narrow. Antennal scale large and broad. *C. simulans.*
  - Areola linear, or obliterated in the middle.
    - Front margin of carapace angulated behind antennæ. *C. gracilis.*
    - Front margin of carapace not angulated. *C. advena, C. Carolinus.*

16. Cambarus simulans.

Plate I, fig. 2, Plate VIII, figs. 3, 3′, 3 a, 3 a′.

Cambarus simulans, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 112, 1884.

Male, form I.—Rostrum broad, deeply excavated; margins raised into sharp crests, which overhang the base of the sides of the rostrum, converging, sinuated before the tip to form the short acumen; no lateral spines; the acumen is barely margined. Post-orbital ridges subacute in front, divergent and ending in slight callosities behind. Carapace ovate, narrowing in front, gastric area smooth, cardiac area lightly punctate, sides granulate; anterior border notched behind the antennæ; cervical groove sinuate, split on the sides, with a minute terminal branchiostegian spine; no lateral spine; areola more than one half as long as the distance from the point of the rostrum to cervical groove, narrow, carinate, expanding into an anterior and a posterior triangular field; two longitudinal dotted lines run along the areola from the anterior triangle to the posterior triangle, which is irregularly and sparsely dotted. Abdomen broad, shorter than carapace, punctate, posterior margins of pleura obliquely convex; hind margin of anterior segment of telson bi- to multi-denticulate on each side, posterior segment short, hind border almost straight; median rib of inner plate of swimmeret ends inside of the margin. Basal segment of antennule with a spine below. Antennæ shorter than

body, second and third segments furnished with minute blunt spinules, scale a trifle longer than the rostrum, very broad, broadest in the middle, truncate at apex, external terminal spine minute. Anterior process of the epistoma triangular, antero-lateral borders convex, rimmed, anterior angle truncate or notched in old specimens, with a projecting median spine. Third maxillipeds densely hairy within and beneath. Chela long, slender, squamoso-tuberculate, internal margin long, straight, strongly dentate; fingers long, punctate, external border of movable finger tuberculate, inner border of both fingers toothed, a prominent tubercle near the base of external finger opposite a more or less clearly marked incision in the base of the thumb. Carpus triangular, obliquely truncate, inner margin armed with a stout spine and some low, scattered tubercles, lower side with two or three teeth and numerous small tubercles. Superior margin of meros with short spines, which are sometimes obsolescent except the distal ones; below, the biserial spines are well developed. Sternum hairy. Third pair of legs hooked. First pair of abdominal appendages strong, straight, internal part with a very small, straight apical spine, which does not reach the end of the external part; external part with two horny terminal teeth, one of which is flat and disk-shaped, the other slender and somewhat curved.

Length, 97 mm. Breadth, 27 mm. Length of carapace, 51 mm. Length of areola, 18 mm. Width of areola, 1.3 mm. Length of rostrum, 11.5 mm. Length of chela, 50.5 mm.

Male, form II.—Chelipeds smaller, hooks on the third pair of legs smaller, first abdominal appendages without horny teeth at apex.

Female.—Chelæ smaller and shorter-fingered than in the male; annulus ventralis bituberculate in front, each tubercle denticulate.

Known Localities. — Texas: Dallas; east of Canadian River (Coll. U. S. Nat. Mus.). Kansas: Fort Hays.

This species is remarkable in having the general form of body and claw of the *C. Blandingii* group of species, while the fact that only the third pair of legs are hooked places it in the *C. advena* group. The male appendages and the female annulus are very near to those of *C. gracilis*. In the shape of the body, areola, antennal scale, and claw, it resembles *C. Blandingii*, var. *acuta*, but the rostrum is deeply excavated, and toothless even in small specimens. The full cephalothorax and large abdomen seem to indicate that it is not a pre-eminently burrowing species, like its allies, *C. gracilis*, *C. advena*, etc.

There are specimens in the United States National Museum collected by

the United States Exploring Expedition West of the Hundredth Meridian in pools east of the Canadian River. This locality, I presume is within the limits of the State of Texas.

17. Cambarus Mexicanus.

Astacus (*Cambarus*) *Mexicanus*, Erichson, Arch. Naturgesch., XII. Jahrg., I. 99, 1846.
? *Cambarus Aztecus*, Saussure, Rev. et Mag. de Zool., 2e Sér., IX. 503, 1857. — Mém. Soc. Phys. Hist. Nat. Genève, XIV. 460, Pl. III. fig. 23, 1858.
Cambarus Mexicanus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 84, 1870. (After Erichson.)
Cambarus Mexicanus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 141, 1884.

Male. — Rostrum sub-plane, margins raised into crests gradually converging until within a short distance of the tip, where the crests become obsolete and the margins of the rostrum suddenly converge, without lateral spines, to form the short-pointed acumen. Post-orbital ridges parallel, obtuse in front. Carapace laterally compressed, of nearly equal width throughout, thickly punctate, sub-orbital angle rounded, cervical groove sinuate, no lateral spine, branchiostegian spine small, blunt; areola narrow, punctate. Abdomen as long and broad as the cephalothorax, telson with three or four small spines on each side, posterior segment short. Antennal scale broad, broadest in the middle. Chela long, subcylindrical, thickly beset with squamous ciliated granules; fingers about the same length as the hand, ciliate, granulate, costate. Carpus hardly sulcate above, covered with granules like the hand; no teeth on the inner margin. Meros granulate, outer surface smooth except on the margins and distal end; a biserial row of spines below. Third pair of legs hooked. Sternum setose. First pair of abdominal appendages short, straight, a rectangular shoulder on the anterior margin near the tip, external and internal parts in close apposition to their tips; external part furnished with a small, slender, procurved, horny spine; internal part flattened within, apex straight, scarcely separated from external part.

Length, 51 mm. Carapace, 25 mm. Length of areola, 8 mm.; width of areola, 0.6 mm.

The above description is drawn up from a specimen in the Academy of Natural Sciences of Philadelphia, received from Mirador, Mexico, through Dr. Sartorius. The hooks on the third pair of legs are well developed, the first pair of abdominal appendages not articulated. I think there is no doubt that this specimen is Erichson's *C. Mexicanus*, the types of which could not be found in the Berlin Museum either by Dr. Hagen or Von Martens.

Cambarus Aztecus, as described and figured by Saussure, has a shorter, flatter hand, and carpus spinous on internal border.* Von Martens (Arch. Naturgesch., XXXVIII. Jahrg., I. 131) would separate it from *C. Mexicanus*. Dr. Hagen has kindly given me the following note on the types of Saussure in the Berlin Museum, which he examined in September, 1870.

"The first form of the male and the female, from Mexico, seem to be *C. Mexicanus* Erichs., with nearly cylindrical hands. The second form, with more flattened hands, belongs alone, then, to Saussure's *C. Aztecus*. In the second form the antennal scale is more broadly truncate in front, and the rostrum is a little different, but these differences are not striking enough to preclude the identity."

A sketch of the first form male appendages, made from one of these types by Dr. Hagen, shows them to be of the same form as in the specimen I have described above.

The female specimens noticed on page 39 under *C. Wiegmanni* have a shorter and broader chela and carpus, the granules on the internal margin of the carpus assuming the character of spinules. As there are no male specimens among them, I am not sure that they are not the female of *C. Aztecus* Saus.; but this point, as well as the identity of *C. Aztecus* and *C. Mexicanus*, I must leave unsettled for lack of material.

Saussure's locality for *C. Aztecus* is, "Les ruisseaux du Mexique. — Pris à Tomatlan, dans les Terres-Chaudes." According to Von Martens (Arch. Naturgesch., XXXVIII. Jahrg., I. 130) there are specimens in the Berlin Zoölogical Museum from Puebla.

18. Cambarus Cubensis.

Plate II. fig. 1, Plate VIII. figs. 5, 5', 5 a, 5 a'.

Astacus (Cambarus) Cubensis, Erichson, Arch. Naturgesch., XII. Jahrg., I. 100, 1846.
? *Cambarus consobrinus*, Saussure, Rev. et Mag. de Zool., 2e Sér., IX. 101, 1857. — Mém. Soc. Phys. Hist. Nat. Genève, XIV. 457, Pl. III. fig. 21, 1858.
Cambarus Cubensis, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 85, 1870. (After Erichson.)
Cambarus Cubensis, Von Martens, Arch. Naturgesch., XXXVIII. Jahrg., I. 129, 1872.
Cambarus Cubensis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 142, 1884.

Male, form I.—Rostrum triangular, moderately excavated, acumen short, acute, small lateral teeth at base of acumen. Anterior end of post-orbital

* "*Cambarus Aztecus*. Rostre court, arrondi au bout. Carènes latérales obtuses, ne se terminant pas en une épine. Carapace ponctuée, granuleuse sur les côtés, à sa portion antérieure, mais sans épines au bord du sillon oblique. Mains médiocres ou petites, comprimées, fortement granuleuses et écailleuses; carpes écailleux, armés de petites épines, en dessous, une double rangée d'épines. Pattes de la troisième paire, chez le mâle, armées, à leur base, d'une apophyse rudimentaire. Long., 2 pouces. — Mexique." — Saussure.

spines acute. Carapace laterally compressed, punctate, fore border slightly angulated behind the antennæ; cervical groove sinuate; no lateral spine; small branchiostegian spine; areola of moderate width, punctate. Abdomen longer than the cephalothorax; anterior segment of telson with two to five spines on each side. Epistoma very short, broad, with an anterior spine. Antennæ long, slender; scale very broad, broadest in the middle, with very small apical spine. Third maxillipeds hairy within. Chela sub-cylindrical, long, slender, densely covered with ciliate, squamous, small tubercles; fingers slender, with an internal and external longitudinal rib. Carpus cylindroidal, hardly furrowed above, squamoso-tuberculate like the hand, one or more of the tubercles on the inner margin spiniform. Meros granulate, with spines on the lower surface and at the distal end of superior border. Sternum lanuginose. Third pair of legs with a long, slender hook on the third joint. First pair of abdominal appendages short, thick, outer part ending in a blunt tubercle, bearing a minute horny tooth directed forwards; the internal part projects far beyond the hind border of the external part, terminating in a slender outwardly directed spine; within, it forms a broad, flat, setose plate; the anterior margin of the appendage has a projecting rectangular shoulder near the tip.

The second form of the male has the hooks on the third legs short and blunt; the external part of the first abdominal appendages has a terminal blunt tubercle in place of the sharp horny tooth of the first form.

The female has shorter, broader, smoother hands; annulus composed of a large anterior bilobed tubercle and a smaller posterior tubercle. In a large number of the females examined the annulus is hardly at all developed.

Length, 56 mm.

Habitat. — Cuba.

Erichson does not describe the male appendages, but Von Martens asserts that in Erichson's types in the Berlin Museum these organs have the same structure as in those described by himself as *C. Cubensis* from Gundlach's Cuban collections: "Die ersten Abdominalfüsse sind eigenthümlich gebildet; obwohl nur aus einem Stück bestehend, lassen sich doch gegen ihr Ende zu zwei mit einander verwachsene Theile unterscheiden, ein äusserer, der in eine stumpfe Spitze endigt und dessen Vorderrand nahe derselben merklich anschwillt, und ein innerer, welcher nach hinten den vorigen überragt, nach innen eine ebene ovale Fläche bildet, welche sich an die des Anhangs der vordern Seite anlegt, und an seinem Ende zwei Lappen zeigt,

einen an das Ende des äussern Theils angelegten und einen zweiten kürzeren frei nach vorn vorstehenden, mehr abgerundeten."

It is exceedingly difficult to elucidate the complex structure of these appendages without the aid of figures; but I think there is no doubt that Von Martens's description appertains to the species described above by myself, from specimens collected by Mr. S. Garman near Havana.

Saussure's types of *C. consobrinus*, also in the Berlin Museum, were examined by Hagen in 1870, and by Von Martens. They consist of two dry female specimens. The acumen of the rostrum is longer than in Erichson's species, and it would seem from Saussure's figure that the lateral spines are more prominent. Saussure mentions a small lateral spine, sometimes obsolete, on the carapace, which does not appear in any of the specimens in the Museum of Comparative Zoölogy. In some of the second form males in the latter collection the chelæ are smaller and comparatively smooth, as Saussure says was the case in some specimens of his *C. consobrinus:* "Souvent les pattes de la première paire sont petites et presque sans caractères, les doigts sans carènes, ponctués au lieu d'être tuberculeux. (Ceci se voit surtout chez les mâles.)" The statement of Saussure, that the *second* joint of the third pair of legs is hooked, is undoubtedly an error for *third* joint. As the male abdominal appendages are not described by Saussure, it is doubtful whether his species be the same as Erichson's. According to Von Martens, specimens in the Berlin Museum make it probable that a second species of Cambarus inhabits the island of Cuba, — a species with a rostrum like *C. Cubensis*, but different sexual appendages.

C. Cubensis finds its nearest kin in *C. Mexicanus*. It is distinguished from that species by its wider areola and toothed rostrum. The male appendages are similar in form, but the inner part is broader, forming a large oval plate. The specimens obtained by Mr. Garman were found in creeks in a little town opposite Havana. According to Saussure, *C. consobrinus* inhabits stagnant pools in Cuba.

The *Astacus fluviatilis major* of Sloane's Jamaica, Vol. II. p. 271, Pl. 245, fig. 2, is a Palæmon, and it is probable that the "common crawfish" of the same author is also a fresh-water prawn. I have seen a specimen of *C. affinis* in the Philadelphia Academy's collection, labelled, "Santo Domingo, W. M. Gabb," but no doubt the locality is erroneous. The only authentic West Indian Cambari are those found in the island of Cuba.

19. Cambarus advena.

Astacus advena, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 402, 1855.
Cambarus Carolinus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 87, Pl. I. figs. 51–54, Pl. III. fig. 165, 1870.
Cambarus advena, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III., Pl. III. fig. 164, Pl. VII., 1870.
Cambarus advena, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 140, 1884.

There is a female type specimen of Le Conte's *Astacus advena* in the Museum of Comparative Zoölogy, and another, also a female, in the collection of the Academy of Natural Sciences of Philadelphia. By some error Dr. Hagen transposed the descriptions of *C. advena* and *C. Carolinus* in his Monograph, so that his descriptions do not agree with his own types of these species in the Museum of Comparative Zoölogy! He gives, under the name of *C. advena*, a full figure of Le Conte's species on Plate VII., and the antennal scale, spine of the second segment of the antenna, and epistoma (from Le Conte's type in the Philadelphia Academy) on Plate III. fig. 164. The male appendages, antennal scale, and epistoma are figured on Plate I. figs. 51–54, Plate III. fig. 165, as *C. Carolinus*.

"Habitat in Georgia inferiore. Hyeme vitam degit subterraneam. Æstate in fossis invenitur." (Le Conte.)

The type of Le Conte in the Museum of Comparative Zoölogy has a spine on the lower side of the first segment of the antennules, as in *C. Carolinus*.

20. Cambarus Carolinus.

? *Astacus* (*Cambarus*) *Carolinus*, Erichson, Arch. Naturgesch., XII. Jahrg., I. 96, 1846.
Cambarus advena, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 86, Pl. I. figs. 90–92, 1870.
Cambarus Carolinus, Hagen (as determined by examination of his type specimen!).
Cambarus Carolinus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 140, 1884.

For the transposition of the descriptions and part of the figures of *C. Carolinus* and *C. advena* in Hagen's Monograph, see above. Hagen's types of these two species in the Museum of Comparative Zoölogy are correctly determined. The larger dimensions given by Hagen (p. 86), 2.9 in., are those given by Le Conte for *Astacus advena*.

Hagen's type, labelled "*Cambarus Carolinus* Er.," and described by him (p. 86) as *Cambarus advena* LeC., is a male of the first form (M. C. Z., No. 232) from Charleston, S. C. It differs from *Astacus advena* LeC. as follows. The rostrum is less triangular and less deflexed, the cephalothorax more

compressed from side to side, the carapace less granulate on the sides, more sparsely punctate; the branchial regions are more closely appressed, so that they bulge upwards on each side of the areolar line, which thus comes to lie in a depression in the median line of the back; the metacarapace is longer in proportion to the procarapace, the distance from the cervical groove to the posterior margin of the carapace being equal to the distance from the cervical groove forwards to the front end of the post-orbital ridge, whilst in *C. advena* it falls considerably short of this; the epistoma is truncate in front, with a median spine; in *C. advena* it is more rounded in front; the antennal scale is a little wider in front, with shorter apical spine; the serrate crest on the inner border of the hand is less prominent, and the lower face of the hand is less clearly impressed at the base of this crest; the carpus is less spinulose within and below, and the line of teeth on the superior margin of the meros is obsolescent, except the two distal ones; the lateral margins of the pleuræ of the abdominal somites are straighter; the posterior segment of the telson is shorter, and the spine at the end of the median rib of the inner blade of the posterior pair of appendages is marginal, while in *C. advena* this rib terminates in a spine some distance inside the margin. The first pair of abdominal appendages are quite different, as will appear by comparison of the figures on the first plate of Hagen's Monograph, bearing in mind that the names of the two species are transposed on this plate. The distinctions noted by Hagen, based on the presence or absence of spines on the lower side of the first segment of the antennule and at the end of the cervical groove, are not good, as the former is present in Le Conte's type of *C. advena* in this Museum, and the latter is also apparent in most specimens of *C. advena*. The statement of Hagen, that "in the larger specimens the hand is more sulcated beneath at the inner margin, and the carpus more spinulose," probably refers to Le Conte's type of *C. advena* in the Philadelphia Academy.

The female specimen in the same jar with the male just noticed differs from the male in so many ways, that I doubt whether Hagen has properly referred it to the same species. Its abdomen is not only very broad, but longer than the cephalothorax, whilst in the male specimen it is considerably shorter than the cephalothorax. The carapace is not strongly compressed in the lateral direction, is more heavily punctate, the areola is not impressed, the epistoma is sharply triangular, the antennal scale broader. The tubercles of the internal border of the hand are less prominent, the external border of the hand is marginate, instead of being rounded and

obsoletely serrate, as in the male. The superior border of the meros is smooth except at the distal end. The terminal spine of the rib on the inner blade of the swimmerets is inside of the posterior margin. The annulus is quite different from that of the other species of this group, viz. *C. gracilis*, *advena*, and *simulans*, and I suspect that this female belongs to a species of the *C. Bartonii* group allied to *C. Diogenes* and *argillicola*.

All the other specimens in the Museum which are referred to *C. Carolinus* by Dr. Hagen are small specimens. No. 3368, dry female from Georgia, L. Agassiz, is certainly *C. advena*. No. 3367 (No. 1850 of Hagen), a young female also from Georgia, resembles *C. advena* in most respects, but the antennal scale is too broad near the tip. No. 230, seven young female specimens from Mobile, Ala., and No. 275, a very young male from the same locality, appear to belong to some species of the *C. Bartonii* group, rather than to the *C. advena* group, the tips of the male appendages being strongly recurved.

I am not certain of the identity of Erichson's species. Hagen examined Erichson's type (a male of the first form) in Berlin, in 1870, and thought it was *C. Bartonii*. Erichson's description, nevertheless, fits the present species very well. The shape of the carapace, the linear areola, the small abdomen, and the crest-like single row of tubercles on the inner side of the hand, certainly seem to indicate this species rather than *C. Bartonii*. Erichson's type was collected by Dr. Cabanis, who informed Dr. Hagen that all the Astacidæ he procured came from near Greenville in the upper part of South Carolina. The specimen in the Museum of Comparative Zoölogy here referred to *C. Carolinus* comes from the seaboard at Charleston. The form of the male appendages of Erichson's type would at once prove or disprove its identity with *C. Bartonii*. If it be the same, the species under consideration must receive a new name, *C. Hageniamus*. The unispinous telson of Erichson's type is probably an abnormal condition, not a specific character.

21. Cambarus gracilis.

Plate VIII. figs. 4, 4', 4'' (first abdominal appendages of male).

Cambarus gracilis, Bundy, Bull. Ill. Mus. Nat. Hist., No. I. p. 5, 1876. — Trans. Wis. Acad. Sci., V. 182, 1882. — Geol. Wis., Surv. of 1873–79, I. 403, 1883.
Cambarus gracilis, Forbes, Bull. Ill. Mus. Nat. Hist., No. I. p. 18, 1876.
Cambarus gracilis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 141, 1884.

Male, form I.—Rostrum of moderate length, depressed, broad, excavated, foveolate at base; margins raised, punctate, slightly converging from the

base to near the tip, where they suddenly converge to form the short, acute, broadly triangular acumen; the acumen is slightly margined. Post-orbital ridges unarmed in front, with posterior callosities. Cephalothorax long, laterally compressed. Carapace smooth and sparsely punctate above, granular on the sides; cervical groove sinuate, no branchiostegian spine; sub-orbital angle moderately developed, rounded; areola linear, with a small anterior and a larger posterior triangular space. Abdomen shorter than the cephalothorax by the length of the rostrum, lateral margins of the pleuræ nearly straight, basal segment of the telson one- or two-spined on each side, posterior segment short, rounded; rib on inner blade of the swimmeret ends inside the margin. Basal segment of antennule with a spine beneath. Antennæ short, scale short and of moderate width. Epistoma triangular, sides convex and setose, anterior angle truncate in some specimens. Third maxillipeds furnished with long hairs within. Chela broad, inflated, punctate, squamoso-tuberculate on the inner part of the upper face of the hand; inner margin of hand serrato-dentate; fingers laterally compressed, punctate; movable finger tuberculate on the outer margin at the base; inner margins of fingers tuberculate. Carpus triangular, obliquely truncate, armed on the internal side with a long strong tooth and one or two smaller teeth and low tubercles; on the lower face there are a small external spine, a strong median anterior spine, and two or three small tubercles between the median spine and the internal tooth. Distal half of superior margin of meros tuberculate, lower face biserially spinulose. Third pair of legs hooked. Sternum hairy. First pair of abdominal appendages long, slender, twisted; internal part cylindrical, straight, apex acute, longer than internal part, bent somewhat outward; external part truncate, terminated by two horny teeth.

Length, 80 mm. Carapace, 45 mm. Width of carapace, 20 mm. Length of metacarapace, 19 mm.

Female.—Abdomen broader, annulus ventralis composed of two crescents flattened and interlocked behind, the anterior horn of each crescent making a prominent denticulated tubercle.

I have not seen the second form of the adult male. Very young males have the first pair of abdominal appendages unarmed at the tip. In the larger male specimens the movable finger is somewhat excised at the base within, and the index has a very prominent tubercle opposite the excision. In younger specimens the antennal scale is broader and more convex within than in mature specimens. Very young ones, taken from the parent, have

long, slender antennæ, and the areola is not reduced to a line in the middle, as it is in larger specimens.

C. gracilis has much the general habit of *C. Diogenes* of the same region, but the male appendages are formed after the fashion of the *C. Blandingii* group. The annulus ventralis of the female is also quite different from that of *C. Diogenes*. Apart from the sexual characters, it is distinguished from *C. Diogenes* by the very prominent single row of teeth on the inner border of the hand, the narrower cephalothorax, etc. It agrees very closely with the male specimen from Charleston, referred by me to *C. Carolinus* Erichs. (p. 54), described by Hagen on page 86, under the name of *C. advena*. The Western species differs, however, in the rostrum, which is more sharply angulated at the base of the acumen, the fore border of the carapace is angulated, the carpus and meros are more spiny, the rib on the internal lamina of the swimmeret terminates in a spine *inside the margin*. The male appendages are like those of *C. Carolinus*. It differs from *C. advena* in the male appendages and shape of rostrum. The annulus ventralis of the female is much like that of C. *advena*, but in that species the anterior tubercles are not sharply multi-denticulate, as in *C. gracilis*. The female of *C. Carolinus* has probably not yet been made known. (See p. 55.) The female specimen (M. C. Z. Cat., No. 3453) mentioned by Hagen, page 82, as an abnormal specimen of *C. obesus*, is *C. gracilis*.

According to Dr. P. R. Hoy, *C. gracilis* burrows in the clay in the prairies near Racine, Wis.; and Professor Forbes states that it is very common along water-courses, in early spring, in the neighborhood of Normal, Ill. Mr. H. Garman informs me that, among hundreds examined from such localities, he has not found a dozen males. Other localities are Lawn Ridge, Ill., Athens, Ill., and Davenport, Ia. There is a type specimen, male form I., received from Professor Bundy, in the Museum of Comparative Zoölogy.

GROUP III. (Type, C. Bartonii.)

Third segment of third pair of legs hooked. First pair of abdominal appendages of the male thick, the inner and outer parts each terminating in a short recurved tooth.

The more typical forms of this group have no lateral teeth on the rostrum, but in *C. extraneus*, *Jordani*, *Girardianus*, *cornutus*, and *hamulatus*, lateral rostral teeth are present. Of these five, only *C. extraneus* was known to Dr. Hagen, who placed it, on account of the rostral teeth, as an aberrant species in the *C. affinis* group. I think the structure of the male appendages is of much greater value in determining the subordinate groups of Cambarus than the form of the rostrum, which presents every condition between one with well-developed lateral teeth and one with entire margins. *C. cornutus* is peculiar in the enormous development of the antennal flagella. *C. hamulatus*, like *C. pellucidus* in Group I., is blind. It has slender chelæ, and resembles *C. pellucidus* a good deal in its general form.

- Rostrum without lateral teeth.
  - Areola broad. Rostrum long, tapering . . . . . *C. acuminatus.*
  - Areola of moderate width . . . . . *C. Bartonii, C. latimanus.*
  - Areola narrow . . . . . *C. dubius.*
  - Areola obliterated in the middle.
    - Rostrum excavated above . *C. Diogenes, C. argillicola.*
    - Rostrum plane above . . *C. Uhleri.*
    - Incertæ sedis . . . . *C. Nebrascensis.*
- Rostrum with lateral teeth.
  - Eyes well developed.
    - Antennæ of normal size. *C. Girardianus, C. Jordani, C. extraneus.*
    - Antennæ with large flagellum, ciliate on inner side. *C. cornutus.*
  - Eyes rudimentary . . . . . *C. hamulatus.*

22. Cambarus Bartonii.

? *Astacus Bartonii*, Fabricius, Suppl. Entomolog. Systemat., p. 407, 1798.
? *Astacus Bartonii*, Bosc, Histoire Naturelle des Crustacés, II. 62, Pl. XI. fig. 1, 1802. (2d ed., II. 40, Pl. XI. fig. 1, 1830.)
? *Astacus Bartonii*, Latreille, Hist. Nat. Gén. et Partic. des Crustacés et des Insectes, VI. 240, 1803. (After Fabricius.)
Astacus ciliaris, Rafinesque, Amer. Monthly Mag. and Crit. Rev., II. 42, Nov. 1817.
? *Astacus pusillus*, Rafinesque, Amer. Monthly Mag. and Crit. Rev., II. 42, Nov. 1817
Astacus Bartonii, Say, Jour. Acad. Nat. Sci. Phila., I. 167, Dec. 1817.
? *Astacus Bartonii*, Desmarest, Consid. Gén. sur la Classe des Crustacés, p. 212, 1825. (After Fabricius.)
Astacus Bartonii, Harlan, Med. and Phys. Researches, p. 230, fig. 3, 1835.
Astacus affinis, Milne Edwards, Hist. Nat. Crust., II. 332, 1837.
Astacus Bartonii, Gould, Rep. Invert. Mass., p. 330, 1841.
Astacus Bartonii, Thompson, Hist. Vermont, Part I. p. 170, 1842. (With a worthless cut.)
Astacus Bartonii, De Kay, Zoölogy of New York, Part VI., Crustacea, p. 22, Pl. VIII. fig. 25, 1844.
Cambarus Bartonii, Girard, Proc. Acad. Nat. Sci. Phila., VI. 88, 1852. (No description.)

Cambarus montanus, Girard, Proc. Acad. Nat. Sci. Phila., VI. 88, 1852.
? *Cambarus longulus*, Girard, Proc. Acad. Nat. Sci. Phila., VI. 90, 1852.
? *Cambarus pusillus*, Girard, Proc. Acad. Nat. Sci. Phila., VI. 90, 1852.
Cambarus Bartonii, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 75, Pl. I. figs. 47–50, Pl. II. figs. 135–139, Pl. III. fig. 166, 1870.
Cambarus Bartonii, Abbott, Amer. Naturalist, VII. 80, 1873. (Habits.)
Cambarus Bartonii, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 639, 1874. (No description.)
Cambarus Bartonii, Bundy, Trans. Wis. Acad. Sci., V. 183, 1882. — Geol. Wis., Surv. 1873–1879, I. 403, 1883. (Cited from Hagen.)
Cambarus Bartonii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 22, 1884.

Known Localities. — Dominion of Canada: St. John, N. B.; Montreal, P. Q. (?) Maine: Houlton and Maysville, Aroostook Co. (Coll. Bowdoin Coll.); Madison, Somerset Co. (Coll. Colby Univ.). Vermont: Burlington, Colchester, and Shelburne, Chittenden Co. Massachusetts: North Grafton, Worcester Co.; Williamstown, Berkshire Co. New York: Lake Champlain; Ellenburg, Clinton Co. (Coll. Peabody Acad. Sci.); Westport (Coll. Yale Coll.) and Elizabethtown, Essex Co.; Fulton Lakes, Hamilton and Herkimer Cos. (Coll. U. S. Nat. Mus.); Canton, St. Lawrence Co. (Coll. L. A. Lee); Port Jervis and Newburg (Rafinesque), Orange Co.; Fishkill, Duchess Co. (Rafinesque); Fallsburg, Sullivan Co.; Sherburne, Chenango Co. (Coll. Yale Coll.); Cazenovia, Madison Co.; Ithaca, Tompkins Co. (Coll. Yale Coll.); Berkshire, Tioga Co.; Genesee River, Rochester, Monroe Co.; Niagara, Niagara Co.; Forestville, Chautauqua Co. New Jersey: Schooley's Mountain; Orange (Coll. Yale Coll.); Trenton (Coll. Peabody Acad. Sci.). Pennsylvania: Bedford and Pattonville, Bedford Co.; Windham, Bradford Co.; Hummelstown, Dauphin Co. (Coll. Peabody Acad. Sci.); Carlisle, Cumberland Co. (Coll. U. S. Nat. Mus.); Berwick, Columbia Co. (Girard); Schuylkill River, near Philadelphia; Chester Co. (Coll. Acad. Nat. Sci. Phila.); Bainbridge, Lancaster Co. (Coll. U. S. Nat. Mus.); McKean Co. (S. I. Smith); Foxburg, Clarion Co. (Girard). Maryland: Harford Co.; Howard Co.; Montgomery Co. (Coll. P. R. Uhler); Frederick Co. (Coll. P. R. Uhler); Washington Co.; Garrett Co.; Cumberland, Alleghany Co. (Girard). District of Columbia: above Washington; Rock Creek, Georgetown. Virginia: Clarke Co. (Coll. U. S. Nat. Mus.); Alexandria Co.; Franklin, Southampton Co.; tributaries of Rappahannock River, Stafford Co.; James River (Coll. Acad. Nat. Sci. Phila.); tributaries of James River, Rockbridge Co. (Girard); Lunenburg, Lunenburg Co. (Coll. L. A. Lee); Bath Co.; Reed Creek, west of Wytheville, Wythe Co.; Holston River, Smyth Co. (Coll. U. S. Nat. Mus.). West Virginia: Williamsport, Grant Co.; South Branch of Potomac River; Glade Creek (Ran-

dolph or Tucker Co. ?); Patterson's Creek; Petroleum, Ritchie Co.; near White Sulphur Springs, Greenbrier Co.; branch of Clinch River, northern base of Clinch Mountains. North Carolina: Kinston; Newman's Fork, Blue Ridge, McDowell Co. Ohio: Marietta (Coll. Bost. Soc. Nat. Hist.); Cincinnati; Yellow Springs; Scioto River, Columbus. Indiana: New Albany; Fall Creek, Indianapolis (Coll. Peabody Acad. Sci.). Lake Superior. Kentucky: Cumberland Gap, Josh Bell Co.; Smoky Creek, Carter Co.; Kentucky River, Little Hickman, Jessamine Co.; Hickman's Landing; Bear Creek, Grayson Springs, Grayson Co.; Mammoth Cave, Edmonson Co. Tennessee: Lineville Cave, near Blountsville, Sullivan Co.; Doe River, Carter Co. (Coll. U. S. Nat. Mus.); Knoxville. Missouri: Osage River (?).

Var. **robusta.**

Cambarus robustus, Girard, Proc. Acad. Nat. Sci. Phila., VI. 90, 1852.
Cambarus robustus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 80, Pl. III. fig. 167, 1870.
Cambarus robustus, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 639, 1874. (Cited from Hagen. No description.)
Cambarus robustus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 143, 1884.

Known Localities. — Dominion of Canada: Humber River (Coll. Acad. Nat. Sci. Phila.) and Don River, Toronto, and Indian Creek, Weston, Province of Ontario. New York: Forestville, Chautauqua Co.; Genesee River, Rochester, Monroe Co.; Sodus, Wayne Co.; tributaries of Racket River, near Tupper's Lake, St. Lawrence Co. (Coll. L. A. Lee); Canton, St. Lawrence Co. (Coll. L. A. Lee); Fulton Lakes, Hamilton and Herkimer Cos. (Coll. U. S. Nat. Mus.); Natural Bridge, Jefferson Co. (Coll. C. H. Merriam). Maryland: Montgomery Co. (Coll. P. R. Uhler). Virginia: Fredericksburg, Spottsylvania Co. Illinois: Decatur, Macon Co. (Coll. Bost. Soc. Nat. Hist.). Tennessee? (Coll. Bost. Soc. Nat. Hist.).

In the Museum of Comparative Zoölogy there is a specimen of *C. Bartonii* (Cat. No. 3358) labelled "Charleston, S. C.?" and three specimens (No. 1101) in the same jar with an Alpheus are marked "Pico, Azores, Miss O. Dabney, May 23, 1860." The latter locality, at any rate, is probably erroneous. Hagen states (p. 77) that he has seen a specimen from Georgia; and I find in the collection of the Boston Society of Natural History this species in the same bottle with a Pagurus and *Hyas coarctatus*, labelled "Savannah, Ga., Dr. H. Bryant." The presence of the marine forms, especially the Northern Hyas, casts doubt on the correctness of the label. The locality label, "Osage River," is marked by Dr. Hagen as being very doubtful.

The centre of distribution of this common Eastern species seems to be the Appalachian Mountain system in Pennsylvania, and the Susquehanna and Delaware Rivers with their tributary streams. To the northward from this region it is found throughout the State of New York, in the basins of the Susquehanna, Delaware, Hudson, and St. Lawrence Rivers. I have seen Massachusetts specimens from Williamstown, Berkshire Co. (Hudson River basin), and from Grafton, Worcester Co. (Blackstone River basin). The Grafton specimens were lately collected by Mr. L. W. Sargent, in a clear, cold spring. I have been unable to obtain any specimens from Rhode Island or Connecticut, but Prof. E. P. Larkin informs me that about forty years ago crayfishes (*C. Bartonii*?) were not uncommon at Westerly, R. I., on the Pawcatuck River near the border of Connecticut. Vermont specimens have been received from Chittenden Co. on Lake Champlain. According to Zadock Thompson, *C. Bartonii* is very common in many of the small streams in the western part of the State. In the State of Maine, it occurs in the valleys of the St. John, Kennebec, and Penobscot.* I have myself seen specimens from Houlton and Maysville, Aroostook Co. (St. John valley), and from Madison, Somerset Co. (Kennebec valley). Other localities in the State from which crayfishes (probably *C. Bartonii*) have been reported are the following: Heron Lake (Thoreau†) and Churchill Lake (A. S. Packard) on Allegash River, a tributary of the St. John; Moosehead Lake and Solon in the Kennebec valley (*fide* Wm. Elder); Lobster Pond (see Thoreau, Maine Woods, p. 99) and Patten in the Penobscot valley. Professors Verrill and Smith, who have explored the neighborhood of Norway, Oxford Co., in the Androscoggin valley, are confident that no Cambari are found in that part of the State. The easternmost point from which *C. Bartonii* has been received is St. John, New Brunswick.

To the westward, *C. Bartonii* extends into the valley of the Ohio River and its tributaries, in the States of Pennsylvania, West Virginia, Virginia, Ohio, Indiana, Kentucky, and Tennessee.

Southerly its range involves the area drained by the rivers that debouch into Chesapeake Bay, in Maryland and Virginia. From North Carolina I have seen specimens collected in the mountain region of the western part of the State (McDowell Co.), and at Kinston in the eastern part of the State

* The St. John and Penobscot are connected by a canal from Telos Lake to Webster Pond, and the divide between the head-waters of the Penobscot and the Kennebec is so low that it is said that in very wet seasons their waters mingle. (See Thoreau, Maine Woods, pp. 36, 250.)

† Maine Woods, p. 237.

(Neuse River basin). It is doubtfully reported from South Carolina and Georgia; but its place seems to be largely taken in those States by the nearly related *C. latimanus*. Lake Superior and Osage River are isolated Western localities from which *C. Bartonii* is reported.

As a rule, *C. Bartonii* prefers the cooler waters of mountain regions or uplands, while the clay bottoms and marshes, both on the east coast and in the Western prairie country, afford the related *C. Diogenes*. According to Dr. C. C. Abbott, *C. Bartonii* in the neighborhood of Trenton, N. J., burrows in the muddy banks of ditches, small streams, and of the Delaware River. He says: "The burrows of *Cambarus Bartonii*, so far as we have discovered them, have all been in the banks of the smaller streams and meadow ditches (and occasionally a colony of burrows in the river bank, where peculiarly favorable), a little below the usual water line." It is not, however, pre-eminently a burrowing species, like its cousin, *C. Diogenes*, being more commonly found under the stones in clear streams and in springs. In the U. S. National Museum are young specimens found in a spring in Clarke Co., Va., the temperature of whose water is 67° F. The observations of Dr. Godman* upon the habits of a burrow-dwelling species probably relate to *C. Bartonii*.

According to Dr. John Sloan, of New Albany, Ind., *C. Bartonii* is found in ponds and still water in that locality, *C. Sloanii* being the common form in the running streams.

The well-known occurrence of *C. Bartonii* with well-developed eyes in the Mammoth Cave of Kentucky is mentioned on p. 41. Mr. A. R. Crandall has also collected it in Lineville Cave, near Blountsville, Tenn.

As might be expected in a species with such an extended geographical range, *C. Bartonii* is subject to considerable variation. The variations affect especially the rostrum, areola, antennal scale, epistoma, and chelæ. In the common Eastern form, the rostrum is short, broad, nearly plane above, the sides nearly parallel from the base to near the tip, where they suddenly converge to form the short acumen. The antennal scale is narrow. The areola is rather narrow, with two or three longitudinal rows of impressed dots. The chelæ are coarsely punctate, the internal margin of the hand subtuberculate, the fingers gaping at base. To the westward, in the Alleghany Mountain region of Virginia, and in the Ohio River basin, specimens are found in which the rostrum is longer and narrower, the margins converging

* Rambles of a Naturalist, with a Memoir of the Author, Dr. John D. Godman, p. 42. Philadelphia, 1859. (Republished from "The Friend.")

more gradually to form the longer acumen. The areola is wider and more punctated, the antennal scale broader at the tip. This is the form described by Girard under the name of *C. montanus*. From this form we easily pass to one with a still more elongated rostrum, hand and fingers scarcely tuberculated, external finger bearded within at the base, antennal scale truncate at the end, with the inner margin straight and parallel to the outer one. The epistoma is short and transverse. This form I have called *C. Bartonii*, var. *longirostris*. It is perhaps the same as Girard's *Cambarus longulus* (see p. 66). My specimens come from Eastern Tennessee and West Virginia. Three from Cumberland Gap have a well-marked lateral spine on the carapace. There are so many varieties connecting this one with the more typical forms with a short rostrum, that I cannot regard it as a distinct species.

Even among those with the short quadrangular rostrum there is considerable variation, the upper surface of the rostrum being more or less hollowed out and the margins thickened, and the areola of variable width. From one locality, Cincinnati, Ohio, come three forms which are readily distinguishable from each other. In one of these (M. C. Z., No. 267) the rostrum is subquadrangular, the antennal scale narrow, and the areola narrow (2 mm. in a specimen 75 mm. long) with two longitudinal lines of dots. This comes very near the common Eastern form, but the rostrum is more excavated above. In another form (M. C. Z., No. 288) the rostrum is also quadrangular, but the areola is broad (4 mm. in a specimen 91 mm. long) and thickly sown with dots. The cervical groove is more sinuate, the post-orbital ridge shorter. The third form (M. C. Z., No. 243) has a somewhat longer and more tapering rostrum, an almost linear areola, antennal scale broad near the tip, and a shorter and more conical hand. This form approaches *C. latimanus*, and may be a distinct species from *C. Bartonii*.

In specimens from the Mammoth Cave, the antennæ are extremely long ($1\frac{1}{3}$ times as long as the body), the antennal scale broad and sub-truncate at the end; the metacarapace is very long, and a lateral spine is evident. The margins of the rostrum are angulated at the base of the acumen, in young specimens even toothed. The terminal segment of the telson is oval. The largest specimen from the cave, a male of the first form, measures 108 mm. from tip of rostrum to posterior border of telson.

Fabricius's description of *Astacus Bartonii* is as follows: —

"A. thorace lævi, rostro brevi, acuminato, carpis dentatis.

"Habitat in America boreali. Prof. Smith Barton.

"A. fluviatili minor. Thorax lævis, punctatus, lateribus antice parum scabris. Rostrum breve, planum, apice acuminatum. Chelæ sex, anticis majoribus, brachiis serratis, carpis dentatis, manibus ovatis, lævibus, punctatis, reliquiis quatuor filiformibus."

As Dr. Barton lived in Philadelphia, the specimen sent by him to Fabricius was probably the species now commonly known as *C. Bartonii*.

Bosc's type probably came from South Carolina, as Desmarest asserts, and may have been some other species. His figure is too defective for identification.

Rafinesque's *A. ciliaris*, from Fishkill, Newburg, etc., N. Y., is without doubt this species, and his description of *A. pusillus* is probably based on small specimens of the same species. It runs thus: "Antens length of the thorax, rostrum oval acute, a thorn and a longitudinal angle behind each eye; three pairs of pinciferous feet, hands of the first oblong dotted, wrist smooth. Obs. A very small species, living in the brooks near Saratoga, Lake George, Lake Champlain, Utica, Oswego, etc. Length one or two inches; vulgar name, brook prawn, shrimp, or lobster; entirely fulvous brown."

Say's description was evidently drawn up from this species, although his supplemental remarks on page 443, where he says it is extremely common in the pine-barren marshes of the Southern States, particularly Georgia and Florida, probably relate to some other species.

Milne Edwards, misled by the transposition of the numbers of Harlan's figures, has described *C. affinis* under the name of *A. Bartonii*; *C. Bartonii* (or a closely related species), under the name of *A. affinis*.

The Museum of Comparative Zoölogy contains specimens of *C. latimanus* from South Carolina, labelled *A. Bartonii* by Dr. Lewis R. Gibbes, and in the collections of the Academy of Natural Sciences of Philadelphia are specimens of *C. rusticus*, var. *placida*, also labelled *A. Bartonii* by the same writer. The localities given by Gibbes for *A. Bartonii*, therefore, cannot be taken as belonging to this species.

Erichson's types of *C. Bartonii* in the Berlin Museum were examined by Dr. Hagen in 1870. They are a male, form II., and a young female, and according to Dr. Hagen both are *C. latimanus*. They were collected by Cabanis in upper South Carolina. Erichson's type of *C. Carolinus*, also from South Carolina, appeared to Dr. Hagen to be *C. Bartonii*, but the description of Erichson agrees much better with the species formerly referred to *C. Carolinus* by Hagen.

Girard does not describe his *C. Bartonii*, but cites as synonymous *A. Bartonii* of Fabricius, Latreille, Bose, Say, Harlan, and Gould, and *A. ciliaris* of Rafinesque. His localities are Foxburg, Carlisle, and Berwick, Pa. Hagen examined a specimen from the latter locality, communicated by Stimpson, undoubtedly one of Girard's types. This specimen agreed perfectly with Hagen's *C. Bartonii* from the Schuylkill River. There is now in the collection of the Academy of Natural Sciences of Philadelphia a dry female specimen labelled "*C. Bartonii*? Cohaxie [Coxsackie?]," in the same handwriting as the other species of Girard mentioned on page 11. It is the typical Eastern form of *C. Bartonii*, with two longitudinal rows of dots in the areola, narrow antennal scale, and short, quadrangular rostrum.

Girard also describes *C. montanus*, sp. nov., *C. longulus*, sp. nov., *C. pusillus*, sp. nov., and *C. robustus* (Raf.). The types of *C. montanus* came from the Alleghany regions in Maryland, Virginia, and West Virginia. A young second-form male type from Greenbrier River, W. Va., was compared by Hagen, and deemed identical with *C. Bartonii*. The young male in the Philadelphia Academy, labelled "*C. montanus*? James River, Va.," said by Hagen to be identical with the type of *C. montanus*, has been examined by me. The rostrum is more oval than in the common form of *C. Bartonii*, the antennal scale broader near the tip, the areola more punctate, with the dots irregularly disposed over the whole field of the areola. It cannot be separated specifically from *C. Bartonii*.

The type of *C. longulus*, from the Middle States, was also examined by Dr. Hagen, and thought to be a deformed specimen of *C. Bartonii*. "The fingers are cylindrical, very widely separated at the base, and bearded in this place and inside of the external finger, along the basal half. . . . . The other differences quoted by Mr. Girard, and taken from the shape of the rostrum and the breadth of the areola, are not important enough to warrant a specific separation." According to Girard's description the areola is very broad, the rostrum much narrower and longer than in *C. Bartonii* and slightly concave on the sides. The specimens described above under the name of *C. Bartonii*, var. *longirostris*, perhaps are the same form as *C. longulus*. They agree with Girard's description in the length of the rostrum, and the external finger is bearded within in accordance with Hagen's description of Girard's type.

Girard's type of *C. pusillus* came from the stomach of a *Lota maculosa* taken in Lake Ontario three miles from shore, off Oswego, N. Y. Compared with

C. montanus, the antennæ were longer, the rostrum was more tapering and terminated in a more elongated point, and the areola narrower. This was probably a form of *C. Bartonii*, whether identical with Rafinesque's *C. pusillus* or no is doubtful.

C. robustus Girard, not an uncommon form in the St. Lawrence valley about Lake Ontario, is so near to *C. Bartonii* that it is best treated as a variety of that species. The differences are sufficiently pointed out by Hagen on page 80 of the Monograph of the North American Astacidæ. They are hardly greater than in some of the varieties of *C. Bartonii* noticed above. Both forms, *C. robustus* and the typical *C. Bartonii*, are found together in some parts of New York State. A male specimen in the collection of the Academy of Natural Sciences of Philadelphia, from Humber River, Toronto, is probably one of Girard's types. There is a male specimen from Decatur, Ill., in the collection of the Boston Society of Natural History, and two small specimens from Tennessee, Dr. Curtis, which appear to be *C. robustus*. In the Philadelphia Academy there is also a young specimen from Florida that resembles *C. robustus*, but the antennal scale is broader at the tip. *C. Bartonii*, var. *robusta*, is also found in Virginia. I have seen specimens 86 millimeters in length.

The first abdominal appendage of the male *C. Bartonii*, var. *robusta*, is figured by Brocchi, Ann. Sci. Nat., 6° Sér., Zool. et Palèontol., II., Pl. XIII. fig. 15.

In the Report on the Crustacea of the United States Exploring Expedition (Pt. I. p. 525, Pl. XXXIII. fig. 2) Dana describes and figures as *Astacus* (*Cambarus*) *Bartonii* a crayfish of uncertain locality, "possibly from Brazil." It is clearly not *Cambarus Bartonii*, neither is it the same as the Brazilian Parastacine crayfish in the Museum of the Academy of Natural Sciences of Philadelphia, as Hagen suggests (p. 11). I have not been able to find Dana's type in the collections of the Smithsonian Institution.

23. Cambarus acuminatus.

Plate III. fig. 5, Plate VIII. figs. 6 a, 6 a'.

Cambarus acuminatus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 113, 1884.

Rostrum long, tapering, ending in a long, sharp acumen, without lateral spines; upper surface smooth, somewhat hollowed out, margins punctate, ciliate, raised into low sharp crests. Post-orbital ridges with sharp anterior

spines. Carapace smooth, punctate, granulated on the sides, cervical groove sulcate, sinuate; a sharp lateral and branchiostegian spine; suborbital angle rounded; an irregular indentation on the side of the carapace, below the lateral spine, on the hepatic region and anterior part of the branchial region; areola broad, smooth, punctate, less than half as long as the distance from the tip of the rostrum to the cervical groove. Telson bispinose on each side. Epistoma triangular, angles rounded. Second and third segments of the antennæ with a strong sharp spine; scale of moderate length, rather broad, inner margin rounded, outer margin thick, turned outwards at the tip. Third maxillipeds hairy within. Chela moderate, punctate, serrato-tuberculate on internal border, fingers setose on their inner margins, external border of outer finger submarginate. Carpus armed with a strong internal spine and smaller inferior median and external spines. Meros with well-developed biserial spines below, and two obliquely placed near the distal end of the superior border. In some specimens one of the superior pair is obsolete. Third pair of legs hooked. First pair of abdominal appendages as in *C. Bartonii*.

Length, 48 mm. Carapace, 23 mm. Rostrum, 6 mm. Areola, 7 mm. Breadth of areola, 2 mm.

Saluda River, west of Greenville, S. C. Collected by Prof. D. S. Jordan. Three specimens, one male of the second form, two females. For the opportunity to examine these I am indebted to Prof. O. P. Hay of Butler University, Irvington, Ind. Differs from the other species of the *C. Bartonii* group in its long, gradually tapering rostrum, short metacarapace, strongly developed spines of carapace, antennæ, and meros. The acumen of the rostrum is scarcely upturned at the tip.

Specimens from North Carolina, Old Fort, McDowell Co., and French Broad River (in Mus. Comp. Zoöl. and Acad. Nat. Sci. Phila.), differ from the above in having the rostrum flatter and less attenuated at the tip, a shorter antennal scale, sub-orbital angle produced into a sharp spine. These may prove to be a distinct species from the Saluda River specimens. They approach *C. Bartonii*, var. *robusta*, but may be distinguished from that form by the longer-pointed rostrum, shorter metacarapace, better-developed spines, etc.

24. Cambarus latimanus.

Plate II. fig. 3.

? *Astacus* (*Cambarus*) *Bartonii*, Erichson, Arch. Naturgesch., XII. Jahrg., I. 97, 1846.
Astacus latimanus, Le Conte, Proc. Acad. Nat. Sci. Phila., VII. 402, 1855.
Cambarus latimanus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 83, Pl. I. figs. 43–46, Pl. III. fig. 162, 1870.
Cambarus latimanus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 144, 1884.

Known Localities.—South Carolina: near Columbia (Coll. U. S. Nat. Mus.); near Greenville (Coll. Berlin Mus., *teste* Hagen). Georgia: Athens; Milledgeville; Roswell. Alabama: Blount Spring and Cullman, Sand Mountain; near Bridgeport (var.). Mississippi: Ocean Springs. Tennessee: near Ashland City, Cheatham Co. (var.).

Erichson's types of *C. Bartonii* in the Berlin Museum were examined by Dr. Hagen in September, 1870. They consist of a male of the second form and a young female collected by Cabanis in the upper part of South Carolina, near Greenville. Hagen considered them both to be young *C. latimanus*. A large *C. Diogenes*, from St. Louis, Mo., with a deformed rostrum, in the same museum, was also labelled *Astacus Bartonii* by Erichson.

There is a type, male form I., of Le Conte's *A. latimanus* in the Museum of Comparative Zoölogy, and another, a female, in the Philadelphia Academy. Two specimens from South Carolina in the Museum of Comparative Zoölogy were received from Dr. Lewis R. Gibbes as "*Astacus Bartonii* Fab."

One male specimen, in the same jar with *C. latimanus*, from Athens, Ga., has a rather broad areola, and seems to be a form of *C. Bartonii*, rather than of *C. latimanus*.

Mr. C. L. Herrick collected small specimens at Ocean Springs, Miss., on the Gulf of Mexico, which appear to be this species, but its favorite habitats are the higher regions at a distance from the coast.

In specimens from Blount Spring and Cullman, Ala., the areola is somewhat narrower than in the types from Georgia; and in those received through the U. S. National Museum from Bridgeport, Jackson Co., Ala., and Ashland City, Cheatham Co., Tenn., the areola is almost reduced to a line in the middle, the metacarapace is longer in proportion to the procarapace, the fingers are shorter, the tuberculation of the hand weaker, the epistoma narrower and less sharply truncate. In the typical specimens from Georgia the distance from the cervical groove to the hind margin of the carapace is equal to the distance from the cervical groove forwards to the middle of

the post-orbital ridges. In the form from Bridgeport and Ashland City it is equal to the distance from the cervical groove forward to the anterior spines of the post-orbital ridge.

25. Cambarus dubius.

Plate IV. fig. 3, Plate VIII. figs. 7, 7'.

Cambarus dubius, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 114, 1884.

Rostrum short, broad, sides subparallel from the base to near the tip, when they suddenly converge to form the short, broadly triangular acumen; the rostrum is angulated, but not toothed, at the base of the acumen; upper surface of rostrum concave, sides thickened, punctate-lined. Post-orbital ridges without spines, slightly swollen at the posterior end. Carapace longer than the abdomen, oval, punctate, granulated on sides, posterior dorsal margin depressed, cervical groove hardly sinuate, crossing the median line of the back half-way between the base of the rostrum and the posterior margin of the carapace; lateral and branchiostegian spines obsolete; sub-orbital angle little developed, obtuse; areola narrow, with two irregular longitudinal rows of dots. Epistoma subquadrangular. Abdomen small, short; anterior segment of telson bispinose on each side, posterior segment rounded behind. Antennæ shorter than the body, second and third segments without spines, scale small. External maxillipeds hairy within. Chela punctate, inner margin of hand serrato-tuberculate, outer margin thickened, serrate; fingers somewhat down-curved, slightly gaping, toothed on their opposed margins. Carpus with a strong tooth on the inner side, teeth of the lower side obsolescent. Superior border of meros serrate, lower side armed with two rows of spines. Third pair of legs hooked. First pair of abdominal legs of the first form of the male short, thick, twisted; internal part cylindrical, recurved, with pointed apex; external part broader, plane within, apex recurved, compressed, external margin corneous, striated.

Length, 62 mm. Carapace, 33.5 mm. Abdomen, 28.5 mm. Rostrum, 5 mm. Metacarapace, 15 mm. Width of areola, 1.5 mm.

Known Localities. — West Virginia: Cranberry Summit, Preston Co. Virginia: Pennington's Gap, Lee Co. Tennessee: Cumberland Gap.

This species has the general appearance of *C. Diogenes*, but the rostrum is short, as in *C. Bartonii*, and the areola is not obliterated in the middle

by the apposition of the branchio-cardiac lines. The few (four) specimens which I have seen come from the Appalachian Mountain region of Virginia and West Virginia. According to Mr. Uhler, it makes mud chimneys like *C. Diogenes*, which it seems to represent in the mountain regions, *C. Diogenes* belonging to the lowlands.

26. Cambarus Diogenes.

Cambarus Diogenes, Girard, Proc. Acad. Nat. Sci. Phila., VI. 88, 1852.
Cambarus obesus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 81, Pl. I. figs. 39–42, Pl. III. fig. 163, Pl. IX., 1870.
Cambarus obesus, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 639, 1874. (After Hagen. No description.)
Cambarus obesus, Forbes, Bull. Ill. Mus. Nat. Hist., No. I. pp. 5, 19, 1876.
Cambarus obesus, Bundy, Proc. Acad. Nat. Sci. Phila., 1877, p. 171. — Trans. Wis. Acad. Sci., V. 183, 1882. — Geol. Wis., Surv. 1873–1879, I. 403, 1883. (No description.)
Cambarus Diogenes, Faxon, Proc. Amer. Acad. Arts and Sci., XX. p. 144, 1884.
Cambarus Diogenes, var. *Ludoviciana*, Faxon, Proc. Amer. Acad. Arts and Sci., XX. p. 144, 1884.

Known Localities. — New Jersey: Mercer Co. Pennsylvania: Derry Station, Westmoreland Co. Maryland: Baltimore Co.; St. Mary Co.; Caroline Co. (Coll. P. R. Uhler); Dorchester Co. (Coll. P. R. Uhler); Worcester Co.; Deer Park, Garrett Co. (Coll. P. R. Uhler). District of Columbia: near Washington. Virginia: Alexandria Co.; Accomack Co.; Northampton Co.; Fredericksburg; Petersburg. North Carolina: Wilmington (Coll. U. S. Nat Mus.); Kinston (Coll. U. S. Nat. Mus.). Ohio: Kelley's Island, Lake Erie (Peabody Acad. Sci.). Indiana: Long Lake, Kendallville, Noble Co. (Bundy); Mechanicsburg, Henry Co. (Bundy); Knox Co. (Coll. U. S. Nat. Mus.). Illinois: Lawn Ridge; Evanston; Belleville; Decatur; Chicago; Abingdon (Coll. L. A. Lee and B. F. Koons). Michigan: Detroit. Wisconsin: tributaries of Pecatonica River, Green Co.; Appleton (Coll. Butler Univ.); Racine (Coll. Acad. Nat. Sci. Phila.). Iowa: Davenport. Missouri: Carroll Co. (Coll. Bost. Soc. Nat. Hist.); St. Louis (Coll. Berlin Mus., *teste* Hagen). Kansas: Leavenworth. Colorado: Clear Lake. Wyoming: Cheyenne. Arkansas. Kentucky: near Louisville? Mill Branch, near Bee Spring, Edmonson Co.? Mississippi: Monticello, Lawrence Co. Louisiana: New Orleans.

The labels of specimens, probably types, of *C. Diogenes* and *C. propinquus*, in the Philadelphia Academy have been transposed accidentally, so that Dr. Hagen failed to see the identity of the former and his own *C. obesus*. Girard's diagnosis is too incomplete to be of much value, although his account of

the peculiar mode of life of this species would serve to identify it to those familiar with its habits.

Specimens from the West are larger than the Eastern examples, and have a broader antennal scale. In many of the Eastern specimens, moreover, the bounding lines of the areola are not so closely approximated as in the Western form, a very narrow linear space being left in the centre. Specimens from New Orleans, La., have a narrower rostrum with the sides nearly parallel, a narrower epistoma, and metacarapace longer in proportion to the procarapace. This form I have called *C. Diogenes*, var. *Ludoviciana*.

A male specimen (M. C. Z., No. 3609) from Detroit, Mich., collected by Mr. H. G. Hubbard from a burrow in blue clay in company with *C. argillicola*, differs from the common Western form in having a narrower, more tapering rostrum, less clearly foveolate at its base, a longer apical spine to the antennal scale, and the post-orbital ridge more interrupted anteriorly to the posterior callosity, which is in the form of a prominent tubercle. The fingers are shorter, giving the chela a more conical shape. The terminal segment of the telson is more oval behind, and the sides of the areola are not so closely approximated. A female specimen (M. C. Z., No. 3458) from the neighborhood of Mammoth Cave agrees very nearly with this male from Detroit. The body is more attenuated than in the ordinary form, in this resembling *C. gracilis*. The other specimens which I have seen from Kentucky are too small to determine with certainty.

I have seen no specimens of *C. Diogenes* from Tennessee, although it probably inhabits that State, judging from the mud "chimneys," similar to those built by this species, collected by Mr. Edward Palmer.

The female noticed by Hagen (p. 82), considered by him to be an abnormal and deformed specimen of *C. Diogenes*, is *C. gracilis* Bundy.

C. Diogenes is pre-eminently a burrowing species, being found in meadows and clay bottoms, often at a great distance from any permanent stream. Girard has given an account of their burrows and the mud "chimneys" which they build over them. His observations were made in the neighborhood of the city of Washington. "The holes, as they appear at the surface of the ground, are nearly circular, from seven tenths of an inch to one inch and one inch and a half in diameter. The depth of the burrows varies according to the locations; this we generally found to be from sixteen inches to two feet, and sometimes to three feet and more. The construction of the burrow itself is often exceedingly simple: from the surface

of the ground the excavation exhibits a gradual slope, in direction more or less undulating for a distance from five to ten inches, when it becomes vertical for six or eight inches, and then terminates in a sudden bottle-shaped enlargement, in which the animal is found. The bottom of the burrow having no subterraneous communication, no other issue except towards the surface, it is entirely isolated from its neighbors, and leaves no chance for escape to its inhabitant. The same burrow may have several external holes connected with it, several inclined channels, which, however, meet at the depth where it becomes vertical. We found constantly the cavity full of water, but this was in March and April. The bottom, for several inches, was filled with soft and pulpy mud.

"There are other instances of burrows somewhat more complex. Their direction may be oblique throughout their whole extent, and composed of a series of chambers or ovoid enlargements succeeding each other at short intervals. Sometimes, also, and connected with one of the chambers, a narrow and nearly vertical tubuliform channel extends downwards to a much greater depth, and appears to us as a retreat either during the cold winters or else during the dryness of the summer, when water is low. That it is not for the mere purpose of escaping pursuit, we infer from the fact that we repeatedly caught the animals in the chambers above, where they remained quietly, instead of attempting to disappear into the apartments below. . . . .

"In the spring, and we are told in the fall also, the burrowing crawfish builds over the holes of its burrow a chimney of the maximum height of one foot, but most generally lower. The chimney, circularly pyramidal in shape, is constructed of lumps of mud, varying in size, irregularly rolled up, and piled up one upon each other, and intimately cemented together. Its exterior has a rough and irregular appearance; whilst the interior is smooth and as uniform as the subterraneous channel, having the same diameter as the latter. . . . .

"The animal works during night. How the work is performed has not yet been ascertained by actual observations. . . . . On an examination of these chimneys, we detected the imprints of the second and third pair of claws, which indicate, evidently, that the parcels of mud, once brought to the surface, ... are arranged and fixed in their definitive place by means of these organs.

"When the work has thus been carried on towards completion, the last

touch consists in shutting up the aperture. This is accomplished by means of several balls of mud, brought up from underneath, deposited temporarily on the edge of the chimney, and drawn back in close contiguity, so as to intercept all communication with the external world."*

Another account of the burrows and mounds of *C. Diogenes*, by R. S. Tarr, has recently been printed, with diagrams, in "Nature," Vol. XXX. p. 127, June 5, 1884.† Mr. Tarr's observations, like Girard's, were made in the neighborhood of Washington. According to Mr. Tarr, the eggs hatch about the middle of May, while the parent is living within her burrow; but Mr. P. R. Uhler tells me that during the period of incubation the female goes into pools, ditches, and quiet waters along the margin of overflowing creeks. Mr. Tarr believes that the chimneys result from the excavation of the burrow, without implying design on the part of the crayfish. Dr. C. C. Abbott,‡ on the contrary, is convinced that they are carefully designed, since they are often built on the steeply sloping banks of ditches, where the ejected balls of mud would surely roll into the ditch if they were regarded by the crayfish simply as rejected matter. In fact, an artistic tower, only two inches in diameter and varying from eight to eleven inches in height, is erected on the steep incline. In several such instances observed by Dr. Abbott the base of the tower was provided for by levelling the ground before the foundation pellets of mud were laid. Of a series of forty towers observed by Dr. Abbott on the banks of a ditch, not one, in his estimation, could have been the result of accident.

As these pages are going through the press, I have received an article by Dr. Abbott,§ which states that his nephew, Mr. Jos. DeB. Abbott, has seen the crayfish engaged in building its chimney. The observation was made in the night by the light of a candle. The crayfish was seen to emerge partially from its burrow, bearing "on the back of its right claw a ball of clay mud which, by a dexterous tilt of the claw, was placed on the rim of the chimney. Then the crayfish remained perfectly quiet for a few seconds, when it suddenly doubled up and dropped to the bottom of its burrow.

* Girard states that Mr. T. R. Peale informed him that he had observed mud chimneys, similar to those built by *C. Diogenes*, in New Grenada, along the Rio Magdalena, several hundred miles from the sea. This observation is of interest, as indicating the possible southward extension of Cambarus beyond the Isthmus of Panama.

† "Habits of Burrowing Crayfishes in the United States."

‡ "Are the 'Chimneys' of Burrowing Crayfish designed?" Amer. Naturalist, Vol. XVIII. p. 1157, November, 1884.

§ "How the Burrowing Crayfish works." The Inland Monthly, Vol. I. pp. 31, 32, Columbus, Ohio, February, 1885.

There elapsed some three or four minutes between each appearance; but every time it came, it brought a ball of clay and deposited it in the manner I have described. About two fifths of the balls were not placed with sufficient care, and rolled down the outside of the chimney."

Dr. Abbott believes that the closing of the orifice of a chimney is merely the result of the accidental falling in of pellets from the rim, loosened perhaps by atmospheric moisture. In some localities where the burrowing crayfish abounds, there is a weather proverb to the effect that, when the crayfish closes the opening of his chimney in dry weather, there will be a rainfall within twenty-four hours.

It is difficult to imagine the object of this crayfish in building these elaborate subterranean abodes. Further observations on the method of tunnelling, on the winter habits of the animal, and on its mode of life during the breeding season, are much needed.

The mud chimneys built by *C. Diogenes* were observed and figured long ago by Audubon (Birds of America, Plates 222, 386; 8vo ed., Plates 360, 370), who describes the ingenious device whereby the White Ibis draws the crayfish from its retreat (Vol. VI. p. 57).

In life *C. Diogenes* is olive-colored, reddish on the margins of the rostrum, the post-orbital ridges, and the margins of the abdominal somites; chelæ cream-colored within, fingers reddish.

The largest specimen which I have seen from the East measures 84 mm. from the tip of the rostrum to the end of the telson. Specimens received from Illinois measure 111 mm. in length.

According to Forbes and Bundy, *C. Diogenes* is one of the commonest species in Illinois and Wisconsin.

27. Cambarus Nebrascensis.

Cambarus Nebrascensis, Girard, Proc. Acad. Nat. Sci. Phila., VI. 91, 1852.
Cambarus Nebrascensis, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 83, 1870. (After Girard.)
Cambarus Nebrascensis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 145, 1884. (After Girard. No description.)

"Rostrum intermediate in form between that of *C. robustus* and *C. Diogenes*. Dorsal lines of suture of the carapace in close contiguity. Large claw nearly conical, giving to the species a very peculiar aspect.

"*Locality.* — Fort Pierre (Nebraska); collected in 1850 by Thaddeus Culbertson." Girard.

This species is unknown to me. Girard places it in his second group of species (*C. Bartonii* and allies), with toothless rostrum and male appendages recurved at their extremity. I am inclined to think that it is a Western form of *C. Diogenes*, or possibly *C. argillicola*. Fort Pierre is on the right bank of the Missouri River, at the mouth of Bad River, within the present limits of the Territory of Dakota. Specimens of *C. Diogenes* collected at Cheyenne, Wyoming, have the hand broad and fingers rather short, so that the chela assumes a triangular shape when the fingers are closed. They do not differ from *C. Diogenes* enough to warrant a separation, but are very likely the form named *C. Nebrascensis* by Girard. I do not know what Hagen means when he says the hands resemble in shape those of *C. Mexicanus*.

28. Cambarus argillicola.

Plate IV. fig. 2.

Cambarus argillicola, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 115, 1884.

Rostrum short, broad, down-curved, excavated, with a deep foveola at base; acumen short, broadly triangular, acute, no lateral spines. Post-orbital ridges without anterior spines, swollen behind. Cephalothorax laterally compressed, carapace punctate, anterior border not angulated, cervical groove sinuate, no lateral or branchiostegian spine. Areola linear in the middle, with an anterior and posterior triangular space, the latter the larger. Abdomen broad, but narrow at the base, longer than the cephalothorax. Telson uni- or bi-spinose on each side. Epistoma rounded in front. Antennal scale small, rounded within. Third maxillipeds heavily bearded within, lightly so beneath. Chela large, hand swollen, denticulate on inner border, irregularly punctate, fingers flattened laterally, punctate and costate; the movable finger has a single row of tubercles on its external border and a very prominent rib on its upper face; its internal, cutting edge is toothed and excised at the base; the outer finger is sharply marginate on its external border, inner border toothed and heavily bearded at the base. Carpus armed with a sharp spine and a few minute tubercles within; beneath them is a sharp median anterior spine, and a minute spiniform tubercle between this and the spine of the internal border. Meros furnished with one or two small subapical teeth on the superior border, and two rows of teeth below. Second pair of legs ciliate near the end. Third pair of legs

of male hooked. First abdominal appendages of male and annulus of female as in *C. Diogenes*.

Length, 76 mm.

Known Localities. — Dominion of Canada: Toronto, Prov. Ontario. Michigan: Detroit, East Saginaw (Coll. Peabody Mus. Yale Coll.). Indiana: New Albany. Louisiana: New Orleans (Coll. U. S. Nat. Mus.). North Carolina: Kinston.

Closely related to *C. Diogenes*, but at once distinguished by the sharply compressed fingers bearded at the base, excised thumb with a single row of tubercles on external margin, non-angulated anterior border of carapace, etc. The types of this species were dug out of burrows in solid blue clay in Detroit, Mich., by Mr. H. G. Hubbard, in August, 1873. The burrows were three to five feet deep. At the bottom of each burrow was a pocket in a layer of loose gravel and clay, holding water. Just above the water line an enlargement in the burrow formed a shelf on which the animal rested.

Specimens from Kinston, N. C., and New Orleans, La., which I have referred to this species, are not adult, and cannot be determined with absolute certainty.

29. Cambarus Uhleri.

Plate VIII. figs. 8, 8′, 8 a, 8 a′ (first abdominal appendages of male *).

Cambarus Uhleri, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 116, 1884.

Male, form I.—Rostrum of moderate length, sides nearly parallel to base of acumen, which is broadly triangular, acute; no lateral spines; upper surface of rostrum plane, punctate, lightly foveolate at base, margins raised into a low, sharp crest, punctate-lineate; there is a faint trace of a median longitudinal carina. Post-orbital ridges without anterior spines, swollen posteriorly. Carapace oval, punctate, granular on sides. Antero-lateral border not angulate or notched. No lateral or branchiostegian spines. Cervical groove sub-sinuate. Areola none. Abdomen longer than cephalothorax. Anterior segment of telson bispinose on each side, posterior segment round behind. Epistoma triangular. Antennæ short, with very small spines on the second and third segments, scale short, broad, inner margin rounded. Third maxillipeds hairy within and beneath. Chela moderate, hand inflated, punctate, ciliate, inner margin ornamented with a row of sharp

* The full figure of *C. Uhleri* was accidentally omitted by the artist.

dentiform tubercles, outside of which is a row of smaller tubercles. Fingers compressed, punctate and costate, movable finger with a single row of tubercles on the outer edge, a prominent rib running along the middle of the upper surface, inner margin excised at base and furnished with tuberculiform teeth; external finger toothed within, hairy at base, outer border marginate. Carpus armed with a strong tooth and a few small scattered tubercles on the inner side, a stout median anterior spine beneath, and two or three smaller ones between the median and internal spine. Superior border of meros serrate, inferior surface with two longitudinal rows of spines. Second pair of legs densely ciliate on the inner side near the tip. Third pair of legs hooked. First pair of abdominal appendages of male and annulus of female as in *C. Diogenes*.

Length, 65 mm. Carapace, 30.5 mm. Rostrum, 6.5 mm.

Known Localities. — Maryland: Caroline Co. (Coll. P. R. Uhler); Dorchester Co.; Talbot Co. (Coll. P. R. Uhler); St. Mary's Co. (Coll. P. R. Uhler); Wicomico Co. (Coll. P. R. Uhler); Somerset Co.; Worcester Co.

This species was discovered by Mr. P. R. Uhler, of Baltimore, in the counties of Maryland enumerated above, on the Chesapeake and Atlantic coasts of Maryland. It is found in salt marshes, covered twice daily by the tides, and also in brackish and fresh-water ditches in company with *C. Blandingii*. In Dorchester County it is found far back in the lowlands in the neighborhood of Vienna.

C. Uhleri is easily distinguished from *C. Diogenes* and *C. argillicola* by its plane rostrum, shape of the hand, etc.

30. Cambarus Girardianus.

Plate IV. fig. 1, Plate IX. figs. 2 a, 2 a'.

Cambarus Girardianus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 117, 1884.

Male, form II.—Rostrum broad, excavated, margins with a line of puncta, slightly convergent; acumen long, ending in a brown corneous upturned tip; a pair of minute, brown horny teeth at base of the acumen. Post-orbital ridges depressed, with sharp anterior spines. Cephalothorax as long as the abdomen. Carapace flattened above, densely and finely punctate, slightly granulated and finely ciliated on the branchial and hepatic regions. Cervical groove sulcate, sinuate, with minute lateral spine, and terminating with a small branchiostegian spine; external angle of the orbit

very prominent, ending in a spinule. Areola long and wide, plane, punctate, in length more than one half the distance between the tip of rostrum and posterior margin of the carapace; sides nearly parallel to within a short distance of the posterior margin, where they diverge. Telson bispinous on each side. Anterior process of epistoma broad. Antennæ longer than the body, scale moderately broad, ending in long, acute apical spine. Third pair of maxillipeds hairy within. Chelipeds moderate; chela large, densely punctate, inner margin short, lightly serrate; fingers long, with parallel rows of puncta, toothed within, outer one bearded within at base. Carpus broad, obliquely truncated, punctate above, with a strong median spine on the inner side and a small double one at the base; below, the carpus is armed with a spine on the anterior border. Meros smooth, with a single ante-apical spine on the upper edge; of the usual biserial spines beneath, only two or three at the proximal end are developed. Thoracic sterna naked. Third pair of legs hooked on the third segment. Fourth pair of legs with a small ovate basal tubercle. First pair of abdominal appendages articulated near the proximal end, stout, short, swollen in the middle; external part with the compressed apex in the form of a strong, obtuse, recurved tooth, double within; internal part recurved, cylindrical, short, acute.

Female.—Annulus ventralis transverse, with a sigmoid sulcus.

Measurements of an individual. — Length of body, 60 mm.; cephalothorax, 31 mm.; abdomen, 29 mm. From tip of rostrum to cervical groove, 20 mm.; from cervical groove to hind margin of carapace, 11 mm. Width of areola, 3.5 mm. Length of rostrum, 7.5 mm.; acumen of rostrum, 2.5 mm.; chela, 20 mm.; inner margin of hand, 7 mm.; fingers, 13 mm.; antennæ, 58 mm.

This species is near *C. extraneus*, but differs in its longer and narrower areola, in the short hand and long fingers, the single superior ante-apical spine on the meros, naked thoracic sterna (in *C. extraneus* they are setiferous), the greater smoothness of the body altogether, and the fineness of the punctation of the carapace; the suborbital angle is very much more projecting than in *C. extraneus*.

This species was discovered by Mr. C. L. Herrick in Cypress Creek, Lauderdale Co., Ala., when collecting under the auspices of the U. S. National Museum, in October, 1882. The specimens obtained were two males, form II., and three females.

31. Cambarus cornutus.

Plate V. figs. 1, 2, Plate IX. figs. 3, 3'.

Cambarus cornutus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 120, 1884.

Male, form I. — Rostrum long, narrow, excavated above; margins divergent at the base, thickened, concave, costate; acumen long, with upturned horny tip; lateral teeth at base of acumen upright, stout, blunt, horny. Post-orbital ridges sulcate on the outer side, with well-developed horny-tipped anterior spines. Carapace flat, smooth and punctate above, granulated on the sides; a depression on each side just outside the orbital ridges; no sub-orbital angle nor spine; cervical groove sulcated, sinuate, with a strong, sharp lateral spine; no branchiostegian spine; areola long, of moderate width, plane, punctate, widening at the posterior end of the carapace. The length of the areola is equal to the distance from the cervical groove to the base of the rostrum. Abdomen broad, as long as the cephalothorax without the acumen of the rostrum, pleura triangular, with sharp lateral angles. Terminal segment of telson broader than long, posterior border rounded; anterior segment of telson bispinous on each side. Anterior process of epistoma very broad, short, triangular; apex not truncated nor notched. Thoracic sterna ciliated. Basal segment of antennule with a spine on lower side on the distal half of the segment. Antennæ longer than the body, flagellum very large, composed of annulations flattened in the vertical direction, conspicuously bearded along the inner margin. Antennal scale oblique to the horizontal plane of the body, a little longer than the rostrum, inner margin straight and parallel with the outer margin, subtruncate at the tip, apical spine strong, long and acute; second segment of antenna with a large external spine at base of the scale; another small but well-formed external spine on the following segment below. Chelipeds large. Chela of moderate size; hand smooth, punctate, internal margin serrate; fingers of moderate length, curved slightly downwards, ribbed and punctate above, tips incurved, horny; external finger serrate on outer margin, impressed above and below at base; inner borders of fingers tuberculate and ciliated especially at their bases. Carpus smooth, lightly punctate above, with a strong median internal spine and a small basal internal spine; a sharp, prominent median anterior spine beneath. Meros smooth, a single acute ante-apical spine on the superior margin, only one or two distal spines in the outer row of biserial spines

beneath. Third joint of third pair of legs hooked. Fourth pair of legs with a conical tubercle on the first segment. First pair of abdominal appendages short, stout, twisted, distal half bent in towards the median line of the body; internal part truncate at apex, with a small spine directed backward and outward; external part longer, ending in a short, recurved, blunt, laterally compressed, horny tooth.

Measurements. — Length of body, 81 mm.; of cephalothorax, 43.5 mm.; of abdomen, 37.5 mm. From tip of rostrum to cervical groove, 27 mm.; from cervical groove to posterior border of carapace, 16 mm. Length of rostrum, 11 mm.; of acumen of rostrum, 5 mm.; of antennæ, 91 mm.; of chela, 36 mm.; of movable finger, 22 mm. Width of base of acumen of rostrum, 3 mm.; of areola, 3 mm.; of chela, 15 mm.

One specimen, collected by Mr. F. W. Putnam in Green River, near the Mammoth Cave, Ky., November 3, 1874.

This species is very distinct from every other known crayfish. In its general appearance it approaches those species included in the group typified by *C. Bartonii*. The rostrum, however, is more after the fashion of *C. rusticus*, but the lateral spines are much larger and stand erect. The impressed external finger recalls *C. Bartonii*, var. *robusta*. The sexual appendages are formed nearly as in *C. Bartonii*. The development of the antennæ is extraordinary.

32. Cambarus hamulatus.

Plate IV. fig. 6, Plate IX. figs. 1 a, 1 a'.

Orconectes hamulatus, Cope and Packard, Amer. Naturalist, XV. 881, Pl. VII. figs. 1, 1 *a*, 1 *b*, Nov. 1881.
Cambarus hamulatus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 145, 1884.

Male, form II. — Rostrum long, subexcavated, foveolate at base, margins moderately raised, converging, lateral spines strong and acute; acumen long, narrow, acute. Post-orbital ridges slightly developed, impressed without; with prominent acute anterior spines. Carapace subcylindrical, flattened above, region posterior to cervical groove long; smooth above, granulated on the sides. A sharp spine on each side at the base of the antennæ at the anterior extremity of the cervical groove, and two or three on each branchial region just behind the cervical groove, one of which is prominent, the other minute. Areola of moderate width, sparsely punctate, sides parallel. Abdomen longer than the cephalothorax, equal to the cephalothorax in width.

Telson long, proximal segment bispinose on each side, distal segment elliptical. Anterior process of epistoma obtusely subtriangular. Eyes rudimentary, concealed under the rostrum. Basal segment of antennules furnished with a sharp spine beneath near the distal extremity. Antennæ shorter than the body, scale equal to the rostrum in length, broad, broadest at the distal end, external border slightly convex, inflated, produced into a long, acute spine. Third pair of maxillipeds bearded within. Chelipeds slender, chela long, slender, subcylindrical, slightly pubescent, inner margin straight, subdentate. Fingers long, slender, subcostate, inner margin straight, hairy. Carpus long, inner side tuberculate, with a sharp anterior spine; two spines on the anterior margin of the lower surface. Upper margin of the meros granulated, with two sharp spines near the distal end; lower surface of the meros furnished with sharp spinules arranged biserially. Third pair of legs hooked. First pair of abdominal appendages fashioned after the type of the *C. Bartonii* group, articulated near the base, short, dilated in the middle, tip bifid, recurved; inner and outer parts forming recurved hooks, the tip of the inner attenuated; outer part double within. The curve of the terminal hooks is not so strong as in *C. Bartonii* and allied species, and the two are closely approximated instead of being separated.

Female. — Body stouter, sternum between the fourth pair of legs smooth, annulus ventralis broad, with a raised rim on the posterior margin, and a wide longitudinal sulcus anteriorly.

Measurements of male, form II. — Length, 44 mm.; of carapace, 21 mm.; of rostrum, 5 mm.; of acumen of rostrum, 2.5 mm. From tip of rostrum to cervical groove, 12 mm.; from cervical groove to posterior border of carapace, 9 mm. Length of abdomen, 23 mm.; of antennæ, 35 mm.; of cheliped, 31 mm.; of chela, 15 mm. Breadth of chela, 3 mm.; of carapace, 8 mm.

Locality. — Nickajack Cave, Tennessee.

I am indebted to Professor Packard for an opportunity to examine four males, form II., and two females of this species, which was discovered by Professor Cope while exploring Nickajack Cave, in the southern part of Tennessee, near the point where the boundary of that State is met by the line which divides the States of Georgia and Alabama. In general form and appearance it bears a close resemblance to *C. pellucidus*, but the carapace is less spiny, and the male has hooks on the third pair of legs only, and the first pair of abdominal appendages are formed after the fashion of the *C. Bartonii* group. The rostrum tapers towards the tip more than it does in the

typical form of *C. pellucidus*, resembling in this respect the form *C. pellucidus inermis*. The terminal segment of the telson narrows at the hinder end more than in *C. pellucidus*. I do not find the differences in the mandibles, antennal scales, and chelæ mentioned by Packard.

33. Cambarus Jordani.

Plate III. fig. 3.

Cambarus Jordani, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 119, 1884.

Male, form II. — Rostrum broad, subplane, sides nearly parallel, acumen long, with minute lateral teeth at base. Post-orbital ridges provided with sharp anterior spines. Carapace punctate (sparsely so on the gastric region), slightly granulated on the sides. A single acute spine on each side of the carapace behind the cervical groove, and a branchiostegian spine on the anterior border. Sub-orbital angle prominent. Areola long, narrow, widening gradually anteriorly, suddenly posteriorly, smooth, with but few puncta irregularly disposed in its field. Abdomen longer than the cephalothorax; proximal segment of the telson bispinous, distal segment rounded posteriorly. Epistoma triangular. Antennæ equal in length to the body minus the telson, scale broad, greatest width toward the distal end, which is sub-truncate and furnished with a sharp external spine. Third pair of maxillipeds hairy within. Chela punctate, ciliate; inner margin of hand short, serrate; fingers long, costate, outer border of movable one serrato-tuberculate. Carpus with a strong, acute median spine, and a small basal spine on inner border; a small spine at each articulation with the chela. Meros smooth on the external surface, two ante-apical spines obliquely placed on the upper edge. First pair of abdominal appendages short, thick, articulated near the base, terminating in two blunt, recurved teeth.

Length of body, 47 mm.; of carapace, 23 mm.; of abdomen, 24 mm.; of rostrum, 6 mm.; of acumen of rostrum, 2 mm. From point of rostrum to cervical groove, 15 mm.; from cervical groove to hind margin of carapace, 8 mm. Width of areola, 1.3 mm. Length of antennæ, 44 mm.

Of this species I have seen but one specimen, a male of the second form, collected by Prof. D. S. Jordan in the Etowah River near Rome, Georgia, communicated by Mr. P. R. Uhler, of Baltimore. It has a toothed rostrum and first abdominal appendages like *C. Bartonii*. It is distinguished from the other allied species by its flat rostrum and narrow areola.

34. Cambarus extraneus.

Cambarus extraneus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 73, Pl. I. figs. 88, 89, Pl. III. fig. 156, 1870.
Cambarus extraneus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 145, 1884.

Known Localities. — Tennessee River near the border of Georgia. Etowah River, Rome, Ga.

Cambarus extraneus, *Girardianus*, *Jordani*, *cornutus*, and *hamulatus* agree in combining the toothed rostrum of the *C. affinis* group with male appendages formed as in the *C. Bartonii* group. The third pair of legs alone are hooked. *C. hamulatus* is at once distinguished by its rudimentary eye-stalks, the great length of the posterior segment of the carapace, and long and slender chelæ. It has the superficies of *C. pellucidus*. *C. cornutus* has strong, erect, lateral rostral teeth, and very thick antennal flagellum, heavily bearded on inner side. *C. Jordani* has a narrow areola with but a few scattered dots, and the antennal scale is broadest toward its tip. *C. extraneus* and *C. Girardianus* have a wide areola thickly sown with dots; they are closely related, but may be separated as follows. In *C. extraneus* the areola is broader and shorter than in *C. Girardianus;* while in *C. extraneus* the section of the carapace behind the cervical groove is never more, usually less, than one third of the entire length of the carapace from tip of rostrum to posterior border, in *C. Girardianus* this section of the carapace is more than one third of the length of the entire carapace. The punctation of the carapace is much coarser in *C. extraneus* than in *C. Girardianus*. The lateral spine of the carapace is very prominent in *C. extraneus*, rudimentary in *C. Girardianus*. In *C. Girardianus* the external orbital angle is very prominent, and ends in an acute spine with a corneous tip; the fingers are longer in proportion to the hand than in *C. extraneus*. The distal end of the meros has a single spine on the upper edge in *C. Girardianus; C. extraneus* has two obliquely placed.

Of *C. extraneus* I have seen nine specimens, of *C. Girardianus* five, of *C. Jordani* one, of *C. hamulatus* six. Among these are males of the second form with the first abdominal appendages articulated and not articulated, but no males of the first form.

The larger female mentioned by Hagen, p. 74, is *C. spinosus* Bundy.

The largest specimen of *C. extraneus* seen by me, a male, form II., with articulated first abdominal appendages, is in the possession of Butler Uni-

versity, Irvington, Ind. It was collected by Jordan in the Etowah River, at Rome, Ga. It measures $3\frac{3}{8}$ inches in length. The areola in this specimen is a little longer and less dilated posteriorly than in the types from the Tennessee River.

The antennæ (mutilated in the type specimens) are nearly as long as the body.

C. extraneus has been found in but two localities, in both places in company with *C. spinosus*.

GROUP IV. (Type, C. affinis.)

Third segment of the third pair of legs of the male hooked. First abdominal appendages of the male bifid, terminated by two nearly straight styliform branches.

Rarely a specimen of *C. virilis* and *C. propinquus* is found with hooks on the third segment of the second, as well as the third, pair of legs, but normally only the third legs are provided with hooks.

The first pair of abdominal appendages in the male are bifid, ending in two free styliform rami. The rami are short, so that the tips reach forward only to the base of the third pair of legs in *C. affinis*, *Sloanii*, *lancifer*, *propinquus*, and *Harrisonii*, while in the other species of the group the rami are elongated to such a degree that they reach forward as far as the base of the second pair of legs, or even to the chelipeds when the abdomen is flexed. In *C. immunis*, *Alabamensis*, *Palmeri*, *Mississippiensis*, and *compressus* the distal part of the long rami is strongly recurved. In *C. lancifer* the terminal rami are short, the outer part almost tooth-like, so that the character of the appendage approaches the type seen in the species belonging to Group I. The shape of the rostrum, antennal scales, and chelæ also mark *C. lancifer* as a passage form between Group I. and Group IV.

The rostrum is commonly armed with a lateral spine in this group, but in *C. medius*, *C. immunis*, and *C. Mississippiensis* the margins of the rostrum are entire, at least in full-grown individuals.

This group corresponds to Hagen's Group II.

The following artificial key may aid in the determination of the species in this group.

- Rostrum without lateral teeth (at least in the adult).
  - Areola linear in the middle. *C. Mississippiensis.*
  - Areola not linear in any part. *C. medius, C. immunis.**
- Rostrum with lateral teeth.
  - Areola linear in the middle.
    - Rostrum and antennal scales very long. *C. lancifer.*
    - Rostrum and antennal scales of moderate length. *C. Palmeri.*
  - Areola of moderate width.
    - Rostrum with a median carina above. *C. Alabamensis, C. compressus, C. propinquus.*
    - Rostrum not carinated.
      - Sides of carapace armed with numerous spines. *C. affinis.*
      - Only one lateral spine on carapace (sometimes obsolete).
        - Rostrum but slightly excavated, or sub-plane. *C. virilis, C. propinquus*, var. *obscura, C. Sloanii.*
        - Rostrum deeply excavated, with raised margins.
          - Margins of rostrum concave. *C. Harrisonii, C. rusticus, C. forceps.*
          - Margins of rostrum straight. *C. propinquus*, var. *Sanbornii, C. spinosus, C. Putnami.*

35. Cambarus lancifer.

Cambarus lancifer, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 59, Pl. I. figs. 86, 87, Pl. III. fig. 159, 1870.
Cambarus lancifer, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 146, 1884.

The only specimen of this species known is Hagen's type from Root Pond, Miss. I cannot find in what part of the State Root Pond is situated.

36. Cambarus affinis.

? *Astacus limosus*, Rafinesque, Amer. Monthly Mag. and Critical Rev., II. 42, Nov. 1817.
Astacus affinis, Say, Journ. Acad. Nat. Sci. Phila., I. 168, Dec. 1817.
Astacus affinis, Harlan, Medical and Physical Researches, p. 230, fig. 2, 1835.
Astacus Bartonii, Milne Edwards, Histoire Naturelle des Crustacés, II. 331, 1837.
Astacus affinis, De Kay, Zoölogy of New York, Part VI. Crustacea, p. 23, 1844. (After Say.)
? *Astacus* (*Cambarus*) *affinis*, Erichson, Arch. f. Naturgesch., Jahrg. XII., I. 96, 1846.
Cambarus affinis, Girard, Proc. Acad. Nat. Sci. Phila., VI. 87, 1852. (Young.)
Cambarus Pealei, Girard, Proc. Acad. Nat. Sci. Phila., VI. 87, 1852. (Adult.)
Cambarus affinis, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 60, Pl. I. figs. 19–22, 84, 85, Pl. III. fig. 152, Pl. V., 1870.
Cambarus affinis, Abbott, Amer. Naturalist, VII. 80, 1873. (Habits.)
Cambarus affinis, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 638, 1874. (After Hagen and Abbott.)
Cambarus affinis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 146, 1884.

Known Localities. — New York: Niagara. New Jersey: Schooley's Mountain, Morris Co.; Red Bank, Monmouth Co. (Coll. Acad. Nat. Sci. Phila.); Trenton; Burlington; Camden Co. (Coll. Acad. Nat. Sci. Phila.). Pennsyl-

* There is a variety of *C. immunis* with lateral rostral spines. See p. 99.

vania: Brandywine Creek (Coll. Acad. Nat. Sci. Phila.); Schuylkill (Coll. Acad. Nat. Sci. Phila.); Reading (Girard); Philadelphia (Coll. Acad. Nat. Sci. Phila.); Bristol; Susquehanna River (Coll. U. S. Nat. Mus.); Bainbridge (Coll. U. S. Nat. Mus.); Carlisle. Maryland: Cecil Co.; Havre de Grace, Harford Co.; Guynn's Falls, Druid Hill, etc., Baltimore Co. (Coll. P. R. Uhler); Anne Arundel Co. (Coll. P. R. Uhler); Montgomery Co.; Charles Co., Potomac River (Coll. P. R. Uhler); Williamsport, Washington Co. (Coll. P. R. Uhler); Cumberland, Alleghany Co. District of Columbia: Washington, Potomac River (Coll. U. S. Nat. Mus.). Virginia: Gunston, Potomac River, Fairfax Co. (Coll. U. S. Nat. Mus.). Lake Erie (Coll. Peabody Acad. Sci.). Lake Superior (Coll. Bost. Soc. Nat. Hist.).

Rafinesque's description of *Astacus limosus* is as follows:—

"N. Sp. *Astacus limosus*. Antens length of the thorax, rostrum equal to their peduncle, one-toothed on each side, canaliculated at its base; a thorn above the eyes, another on each flank, three pairs of pinciferous feet, bearded at their articulations, hands short, smooth, unarmed. — Obs. I discovered this species in 1803, and observed it again in 1816, in the muddy banks of the Delaware, near Philadelphia; vulgar name, mud lobster; length from three to nine inches; good to eat; commonly brown, with an olivaceous tinge."

From the habitat it is probable that this imperfect description refers to the species well described in the following month by Say under the name of *A. affinis*, as assumed by Girard and Hagen.

A dry male specimen in the Academy of Natural Sciences of Philadelphia, No. 127[b], "Schuylkill. Dr. Harlan," is probably Harlan's type.

Milne Edwards, apparently misled by the transposition of the numbers of Fig. 2 and Fig. 3 on Harlan's plate, has described this species as *Astacus Bartonii*; *A. Bartonii* as *A. affinis*.

Erichson's type, a female, in the Berlin Museum, was examined by Hagen in September, 1870. The specimen is stated by Erichson to have been collected in Carolina by Cabanis. The label only gives *America borealis*. Dr. Cabanis assured Dr. Hagen that he collected all his Astacidæ in a rivulet near Greenville, in the northwestern part of South Carolina. No other specimen of *C. affinis* has been reported from that State, and I suspect that Erichson's type belongs to the closely allied *C. spinosus* Bundy, which has been found in the Saluda River, S. C., by Prof. D. S. Jordan. In the museum of the Academy of Natural Sciences is a specimen of this species (No. 127)

from Red Bank, N. J., Dr. Jos. Leidy, labelled "*A. affinis* (*fide* L. R. Gibbes)." Gibbes states that his own specimens came from Florida. They probably belonged to some other species. Hagen states that Gibbes's types of *A. Bartonii* in the Academy of Natural Sciences of Philadelphia are *C. affinis*, but they are in fact *C. placidus* Hagen (Nos. 126[a], 126[c]).*

Types, male and female, of Girard's *C. affinis*, from Reading, Pa., collected by Professor Baird, were communicated to Dr. Hagen by Dr. Stimpson. The male belonged to the second form; the specimens were young, with only one lateral thoracic spine. I have myself discovered in the collection of the Smithsonian Institution four types (two males, two females) of *Cambarus Pealei* Girard (Smithson. Cat. No. 2081), from the Potomac River, Washington. The largest is $4\frac{1}{4}$ in. in length, the smallest $3\frac{1}{8}$ in. They are the adult *C. affinis* Say. These are the only types of Girard's Cambari now in existence, as far as I can discover. The rest were probably burned when loaned to Stimpson, in the great fire of Chicago.

Color. — Upper surface greenish, mottled with darker green, especially on the chelæ; tips of fingers orange, preceded by a dark green ring, which runs along the outer border of the hand to the wrists; abdominal somites ornamented with interrupted transverse chestnut-colored double bands. Under surface of a lighter hue. In recent alcoholic specimens the bands of the abdomen turn bright blood-red.

In some specimens the basal segment of the telson has *three* spines on each side of its posterior margin.

The centre of distribution of *C. affinis* appears to be the great rivers which empty into the Delaware and Chesapeake Bays.

According to Dr. C. C. Abbott (American Naturalist, VII. 80, 81), "*Cambarus affinis* is apparently *the* river species at Trenton, N. J. We have been able to find it, as yet, only in the Delaware River, usually frequenting the rocky bed, but also, in fewer numbers, on the mud-bottomed portions of the river. They are usually found resting under flat stones, well out from the banks of the stream, where the water is of considerable depth. Wherever the vegetation is dense we have failed to find them; nor have we seen anything to indicate that it is a burrowing species."

Since this was written, Dr. Abbott and myself have taken *C. affinis* in great numbers from shallow ditches in the Delaware meadows near Trenton, N. J., in company with *C. Blandingii*.

* See p. 114.

According to Mr. P. R. Uhler, *C. affinis* is the common form in the warmer parts of the rivers and creeks of Maryland, underneath stones. In his collection are specimens from Montgomery Co., labelled as found in "stagnant pools," and specimens from Alleghany Co., four miles below Cumberland, were taken from "holes in the bottom and sides of a canal."

A female alcoholic specimen of *C. affinis* in the Academy of Natural Sciences of Philadelphia is labelled "Santo Domingo, W. M. Gabb." The locality is doubtless erroneous.

In young specimens of *C. affinis* the lateral thoracic spine on the cervical groove is single, and the spinules of the hepatic region are reduced to a mere granulation. Very small individuals closely resemble small examples of *C. propinquus*, as Hagen observes. The body, however, in the young *C. affinis* is more pubescent, the rostrum is not carinated, and the hand is differently shaped. The specimens in the Museum of Comparative Zoölogy from Niagara, referred to *C. affinis* by Hagen, are all very young (the largest measuring $1\frac{3}{5}$ in.), but I think there is no doubt of the correctness of the determination.

C. affinis is the common crayfish exposed to sale in the markets of New York and other Eastern cities.

37. Cambarus Sloanii.

Plate IV. fig. 5, Plate X. figs. 1, 1′, 1 a, 1 a′.

Cambarus Sloanii, Bundy, Bull. Ill. Mus. Nat. Hist., No. I. p. 24, 1876. — Proc. Acad. Nat. Sci. Phila., 1877, p. 172.
Cambarus Sloanii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 147, 1884.

Male, form I. — Rostrum wide, subexcavated, plane towards the tip, margins nearly parallel, acumen long, triangular; lateral teeth small in full-grown specimens, in some individuals reduced to an angle merely. Post-orbital ridges with very small anterior spines, or none. Carapace flattened above, punctate, lightly granulate on the sides, lateral spines acute, anterior border distinctly angulated, areola wide. Basal segment of telson two-spined on each side. Antennal scale a little longer than the rostrum, of moderate width. Anterior process of epistoma broad, excavated, emarginate in front. Third pair of maxillipeds hairy within, naked below. Chela short, broad, inner margin with a double series of depressed teeth; outer finger wide at base, furrowed above near the outer and inner margins; inner finger

curved, costate above; the two fingers are furnished with blunt tubercles on their opposed margins, which touch one another only at their tips. Carpus with a strong inner tooth. Third pair of legs hooked. First pair of abdominal appendages stout, bifid; rami short, acute, outer one with its tip turned outwards, inner one with its tip turned inwards; tips brown, horny.

Male, form II. — The fingers are less gaping, the hooks on third pair of legs small, the first pair of abdominal appendages are bifid for a less distance from the tip, the rami are swollen, without horny tips; these appendages may or may not be articulated near the base.

Female. — Chela like that of the male, form II. Annulus ventralis with anterior border depressed, posterior border elevated, tuberculate, tubercle divided longitudinally by a sinuous furrow.

Known Localities. — Indiana: New Albany. Kentucky (Bundy).

I have seen two of the types of this species, male form I. and female, in the collection of the Peabody Academy of Science, Salem, Mass. Dr. Sloan has also sent me specimens taken at the same time with those sent to Bundy for description, and there are specimens from the same source in the collections of the Boston Society of Natural History, the Peabody Museum of Yale College, and Butler University, Irvington, Ind.

Dr. Sloan writes me that this is the common species in running streams at New Albany, while *C. Bartonii* is the form found in still waters. According to the same gentleman, as quoted by Bundy, this is a burrowing species. "He commences on the bank of the stream, burrows below the bed, and has an opening two or more feet out in the stream, where he sits watching for anything that may turn up, with a safe retreat."

C. Sloanii closely resembles *C. propinquus*, var. *obscura*, in general appearance, but may be at once distinguished by the male appendages and the annulus ventralis of the female. In the latter species the anterior border of the annulus is prominently bituberculate, whereas in *C. Sloanii* the anterior rim is sunk below the level of the sternum in front of it.

The largest specimen seen by Bundy measured $3\frac{1}{2}$ inches in length. The largest I have seen, a female, is a little less than three inches long.

38. Cambarus propinquus.

Cambarus propinquus, Girard, Proc. Acad. Nat. Sci. Phila., VI. 88, 1852.
Cambarus propinquus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 67, Pl. I. figs. 31–38, Pl. III. fig. 153, 1870.
Cambarus propinquus, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 638, 1874. (No description.)
Cambarus propinquus, Forbes, Bull. Ill. Mus. Nat. Hist., No. I., pp. 4, 19, 1876.
? *Cambarus propinquus*, Bundy, Proc. Acad. Nat. Sci. Phila., 1877, p. 171. — Trans. Wis. Acad. Sci., V. 181, 1882. — Geol. Wis., Surv. 1873–79, I. 402, 1883. (No description.)
Cambarus propinquus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 147, 1884.

Known Localities. — Dominion of Canada: Montreal (Coll. Peabody Mus. Yale Coll.); Toronto. New York: Grass River, St. Lawrence Co. (Hagen); Canton, St. Lawrence Co. (Coll. L. A. Lee); Black Lake, St. Lawrence Co.; Ogdensburg (Coll. U. S. Nat. Mus., Young); Lake Ontario (Girard); Garrison Creek, Sackett's Harbor (Girard); Four-Mile Creek, Oswego (Girard); Oneida Lake; Cayuga Lake (S. I. Smith); Rochester; Niagara; Forestville, Chautauqua Co. Indiana: Elkhart River, Rome City, Noble Co. (Bundy); Delphi; Indianapolis (Coll. Peabody Acad. Sci.); Michigan City (Coll. Acad. Nat. Sci. Phila.); Turman Creek, Sullivan Co.; Clear Creek, Bloomington; White River (Coll. Bost. Soc. Nat. Hist.); Switz City (Coll. C. H. Gilbert). Illinois: Freeport, Stephenson Co. (Forbes); Ogle Co.; Geneva, Kane Co. (Coll. Peabody Mus. Yale Coll.); Pekin, Tazewell Co. (Forbes); Normal, McLean Co. (Forbes); Decatur, Macon Co.; Aux Plains River (Coll. U. S. Nat. Mus.). Michigan: St. Clair River; Detroit River; Northville (Coll. U. S. Nat. Mus.); Huron River, Ann Arbor (Coll. Bost. Soc. Nat. Hist., Peabody Acad. Sci., Acad. Nat. Sci. Phila.); Ecorse (S. I. Smith); Kalamazoo River, Otsego (Coll. Bost. Soc. Nat. Hist.). Lake Superior. Wisconsin: tributaries of Pecatonica River, Green Co.; Madison (Coll. Peabody Mus. Yale Coll.). Iowa: Davenport; Des Moines River, Ottumwa.

Var. Sanbornii.

Plate V. fig. 3, Plate IX. figs. 10, 10′, 10 a, 10 a′.

Cambarus Sanbornii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 128, 1884.

Known Localities. — Kentucky: Smoky Creek, Carter Co. Ohio: Oberlin.

Var. obscura.

Cambarus obscurus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III., p. 69, Pl. I. figs. 72–75, Pl. III. fig. 154, 1870.

Cambarus obscurus, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 639, 1874. (After Hagen. No description.)

Cambarus obscurus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 148.

Known Localities. — Genesee River, Rochester, New York.

Girard's diagnosis of *C. propinquus* is too imperfect to avail in the determination of the species, but fortunately Dr. Hagen identified it by examination of one of Girard's types.

In the Academy of Natural Sciences of Philadelphia there is a dry male specimen of *C. propinquus* which was labelled "*C. Diogenes*? District of Columbia," when the collection was examined by Hagen. The original label of this specimen is now lost, but the box contains Dr. Hagen's label, "*C. propinquus* Gir. (*C. Diogenes* Gir.?)," and the tablet to which the specimen is fastened carries a label with the locality "District of Columbia." A dry specimen of *C. obesus* Hag. in the same museum is labelled "*C. propinquus*? Garrison Creek, Sackett's Harbor." The labels of these two specimens were undoubtedly transposed by accident.

I am not sure that Bundy's *C. propinquus* is this species, as I have not seen his types. He says that there is "in these crawfishes a tendency manifested toward multiplication of the lateral thoracic spines, there being in some individuals two and in others three of these on each side." This tendency does not appear in any specimens that I have seen. It is an abundant species in Wisconsin, in company with *C. virilis*.

Smith says that the crayfish found in the valley of the Aroostook River in Maine and New Brunswick is most likely *C. propinquus*. It is really *C. Bartonii*.

In the variety that I have named after the late Mr. F. G. Sanborn (*C. Sanbornii*, Proc. Amer. Acad. Arts and Sci., XX. 128) the first abdominal appendages are less deeply bifid, the rami closer together, than in the typical *C. propinquus*. The rostrum is not carinate, the chela is finely pubescent, the inferior median anterior spine of the carpus is evident. This variety was collected by Mr. Sanborn in Carter Co., Ky., and I have received additional specimens from Prof. B. F. Koons collected at Oberlin, Ohio. Small individuals closely resemble young specimens of the typical *C. propinquus*,

C. affinis, and more closely *C. Putnami;* but the young of the first may be distinguished by the carinated rostrum; of the second, by the longer rostral acumen, antennal scale, and anterior spine of post-orbital ridge, by the longer hand and internal carpal spine, and by the divergent tips of the first pair of abdominal appendages in the male; of the third, by the longer-spined antennal lamina, and the long, deeply cleft abdominal appendages of the male.

In *C. obscurus* Hag., which I deem a local form of *C. propinquus*, the rostrum is somewhat broader, not carinate above, and less deeply hollowed out than in the typical *C. propinquus;* the hand is broader, with a few tubercles disposed in a longitudinal row opposite the base of the movable finger; the fingers are more widely separated at the base, the epistoma more truncate; the male appendages have a projecting angle or shoulder on the anterior margin at the base of the rami, the outer part often grooved longitudinally on the outer side. This form has been discovered only at Rochester, N. Y. The differences between it and *C. propinquus* are so slight that I consider it only a variety. Some specimens of *C. propinquus* show a strong tendency to develop the projecting shoulder on the front border of the male appendages.

In the United States National Museum is a small first-form male of a Cambarus labelled "California" (No. 2531), which I cannot distinguish specifically from *C. obscurus*. The areolar part of the back of the carapace is a little flatter, and the row of small tubercles on a line with the middle of the base of the movable finger is not apparent; but this often happens in small specimens of *C. obscurus*. The locality of this specimen is very probably erroneous, as no other specimen of a Cambarus from the west coast is known.

Hagen thinks that *C. obscurus* may be the *Astacus fossor* of Rafinesque. Rafinesque's description is as follows: —

"*Astacus fossor*. Antens length of the body, rostrum short, one-toothed on each side, a thorn behind the eyes; three pairs of pinciferous feet, hands of the first pair very large, granular, gaping, toothed, with a furrowed and bispinous wrist. — Obs. Vulgar name, burrowing lobster, — communicated to me by Dr. Samuel L. Mitchill, — native of Virginia, Pennsylvania, and New York; size from four to six inches; it burrows in meadows and milldams, which it perforates and damages."

It is impossible to determine what species is here meant. The description would suit *C. propinquus*, a commoner form, as well as *C. obscurus*.

Neither of these forms has been reported from Pennsylvania or Virginia. The only species known to me to be common to the three States of New York, Pennsylvania, and Virginia are *C. Bartonii*, *affinis*, and *Bartonii*. Rafinesque's description fits none of them. Girard surmised, from the habits of *C. fossor*, that it might prove to be *C. Diogenes*.

In the collections of the Boston Society of Natural History and the Museum of Comparative Zoölogy (Cat. No. 3590) there are three second-form males of a Cambarus which closely resemble *C. propinquus*, but the sexual appendages are longer, as in *C. rusticus*. The epistoma is long. The carpus has a strong internal median carpal spine and a small basal internal spine; beneath, the carpus is unarmed. The biserial spines of the meros are well developed. The outer ramus of the first abdominal appendages is a little recurved at the tip. The largest of these specimens is 75 mm. long. No locality is given. They seem to belong to an undescribed species.

39. Cambarus Harrisonii.

Plate III. fig. 1, Plate IX. figs. 9, 9.

Cambarus Harrisonii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 130, 1884.

Male, form I. — Rostrum long, narrow, deflexed, excavated; margins thickened, a little convergent; acumen of moderate length, triangular, acute; marginal spines short, obtuse, often obsolescent. Carapace flattened above, coarsely punctate, granulate on the sides; post-orbital ridges prominent, sulcate without, with acute anterior spine; antero-lateral margin notched at base of antenna; cervical suture not sinuate, interrupted on the side; lateral spine small, acute; branchiostegian spine obsolete; areola at least one half as long as the distance from the tip of the rostrum to the cervical groove, of moderate width, punctate, the dots tending to a biserial arrangement in the middle portion. Abdomen as long as the cephalothorax; telson long, posterior margin rounded, posterior margin of basal segment bispinous on each side. Basal segment of antennule with an internal, subapical, inferior spine. Antennæ as long as the body; second segment armed with a short, acute, external spine; scale as long as the rostrum, of moderate width, widest near the middle, thence tapering to the acute external apical spine. Anterior process of epistoma with convex sides, apex blunt or truncate. Third pair of maxillipeds hairy within. Chelipeds of moderate length, thick; chela large, broad, coarsely punctate above and below, inner margin

of hand with two or three rows of depressed ciliate tubercles; fingers costate and punctato-lineate, gaping, inner margins with rounded tubercles; movable finger incurved; carpus punctate above, armed with an acute median internal spine and two inferior spines (a large median and a minute external). In some specimens there are one or two small antennal basal tubercles. Meros smooth without, two obliquely disposed superior sub-apical spines; of the biserial inferior spines only a few of the distal ones in each row are developed. Distal end of second pair of legs ciliate. Third segment of third pair of legs hooked. First pair of abdominal appendages short, reaching to the base of third pair of legs, thick, split for a short distance from the tip; outer part longer than the inner; tips recurved, brown and horny.

Female. — Fingers less widely gaping, outer one ciliate within at base. Abdomen broader. Sternum between fourth thoracic legs smooth. Annulus ventralis a transverse ridge, thickest in the middle, where there is a rounded tubercle divided longitudinally by a sinuous groove. Between the ridge and the sternal plates of the fourth pair of legs there is a deep transverse fossa.

Measurements of a male, form I. — Length of body, 60 mm. Length of carapace, 30 mm. Length of abdomen, 30 mm. From end of rostrum to cervical suture, 20 mm. From cervical suture to posterior border of carapace, 10 mm. Length of rostrum, 10 mm. Breadth of rostrum at base, 4 mm. Length of rostral acumen, 3 mm. Width of areola, 1.5 mm. Length of antennæ, 60 mm. Length of chela, 25 mm. Breadth of chela, 12 mm. Length of movable finger, 17 mm. Internal border of hand, 7 mm.

In one specimen, a male, form I., the fingers are very much elongated, not gaping at base. The length of the internal border of the hand in this specimen is 7.5 mm.; the length of the movable finger, 21 mm.

Locality. — Irondale, Mo. Collected by E. Harrison.

This species resembles *C. rusticus* in its general form. The male appendages, as well as the annulus ventralis of the female, however, are very different from those of any previously described species. The male appendages approach in form those of *C. propinquus* more nearly than any other, but in that species these appendages are more deeply bifid, and not recurved.

The second form of the male is unknown.

40. Cambarus virilis.

Cambarus virilis, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 63, Pl. I. figs. 23–28, Pl. II. figs. 128–132, Pl. III. fig. 155, Pl. VIII., 1870.
Cambarus virilis, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 638, 1874. (After Hagen. No description.)
Cambarus virilis, Forbes, Bull. Ill. Mus. Nat. Hist., No. I. pp. 4, 19, 1876.
Cambarus debilis, Bundy, Bull. Ill. Mus. Nat. Hist., No. I. p. 24, 1876. — Trans. Wis. Acad. Sci., V. 181, 1882. — Geol. Wis., Surv. 1873–1879, I. 403, 1883. (Male, form II.)
Cambarus virilis, Bundy, Proc. Acad. Nat. Sci. Phila., 1877, p. 171. — Trans. Wis. Acad. Sci., V. 180, 1882. — Geol. Wis., Surv. 1873–1879, I. 402, 1883.
Cambarus Couesi, Streets, Bull. U. S. Geolog. Geograph. Surv. Terr., III. 803, 1877.
Cambarus virilis, Streets, Bull. U. S. Geolog. Geograph. Surv. Terr., III. 804, 1877.
Cambarus virilis, Herrick, Tenth Ann. Rep. Geolog. Nat. Hist. Surv. Minnesota, p. 253, 1882.
? *Cambarus Couesi*? Bundy, Geol. Wis., Surv. 1873–1879, I. 402, 1883. (No description.)
Cambarus virilis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 147, 1884.

Known Localities. — Dominion of Canada: Lake Winnipeg; Saskatchewan River; Red River of the North; Toronto (Peabody Acad. Sci.); Montreal (?). Dakota: Red River of the North near Pembina; Souris or Mouse River. Minnesota: Lake Superior (C. L. Herrick); Mississippi River (C. L. Herrick); Lake Minnetonka (C. L. Herrick), Minnehaha Creek, Cedar Lake (Coll. U. S. Nat. Mus.), Bassett's Creek (Coll. U. S. Nat. Mus.), and Lake Independence, Hennepin Co. Wisconsin: Appleton; Ironton, Baraboo River; Sauk City, Wisconsin River (W. F. Bundy); Sugar River (Coll. Peabody Acad. Sci.); Rock River (S. A. Forbes); Jefferson (W. F. Bundy); Milwaukee (Coll. U. S. Nat. Mus.). Iowa: Davenport; Burlington; Fort Dodge (Coll. Bost. Soc. Nat. Hist.); Spring Vale (Coll. Peabody Acad. Sci.); Des Moines River (Coll. U. S. Nat. Mus.); Bedford (Coll. U. S. Nat. Mus.). Nebraska: Omaha. Wyoming: near Laramie City. Kansas: Leavenworth (Coll. Acad. Nat. Sci. Phila.); Manhattan (Coll. Acad. Nat. Sci. Phila.); Republican River, northwest of Fort Riley (Coll. Acad. Nat. Sci. Phila.); Ellis (Coll. Peabody Acad. Sci.). Missouri: St. Louis (Coll. P. R. Uhler); Osage River; Irondale. Illinois: Quincy, Adams Co.; Lawn Ridge, Marshall Co.; Decatur, Macon Co.; Normal, McLean Co. (S. A. Forbes); Pekin, Tazewell Co. (S. A. Forbes); Cairo, Alexander Co. (S. A. Forbes); Geneva, Kane Co. (Coll. Peabody Mus. Yale Coll.); Stillman's Creek, Marion, Ogle Co. (Coll. Bost. Soc. Nat. Hist.). Indiana: Michigan City, Lake Michigan (Acad. Nat. Sci. Phila.); Long Lake, Kendallville (W. F. Bundy); Elkhart River, Rome City (W. F. Bundy). Alabama: near Bridgeport, Jackson Co. (Coll. U. S. Nat. Mus.). Arkansas: White River, Eureka Springs, Carroll Co. (Coll. U. S. Nat. Mus.). Texas. New York: Lake George (?).

Cambarus virilis is subject to some variation in the shape of the rostrum, the punctation of the carapace, breadth of areola, etc., as Hagen pointed out in his account of this species, p. 64. Yet it is not liable to be confounded with any other species if good-sized specimens are at hand.

I have noticed in a few second-form (?) males of this species an interesting variation from the ordinary type of the first pair of abdominal appendages. In most examples these appendages are split for a considerable distance from the tip, and the two rami are drawn out to a point at the tip. In the other specimens the whole appendage is stouter, the prominences more pronounced, the extremity is split to a less distance from the tip, and the ends of the rami are blunt, almost tuberculate. The hooks on the third pair of legs are well developed, as in the first-form male. The abdominal appendage is not articulated, but this is sometimes the case in the other and commoner type of abdominal appendage of the second-form males. I have found both these forms together in collections made at several places (Lake Superior, Lake Winnipeg, etc.), and the differences in the sexual appendages are not accompanied by any that would indicate a new species.

A specimen of *C. debilis* from Baraboo River, Ironton, Wis., sent by Mr. Bundy, is the second form of the male of *C. virilis*.

Males are occasionally found with small hooks on the third segment of the second pair of legs, as well as on the third pair.

From the U. S. National Museum I have received the types of Street's *C. Couesi* and *C. virilis*. The differences between the two are very slight, and do not warrant their separation as two distinct species. Some of Hagen's types of *C. virilis* from the Red River of the North and the Saskatchewan River are of precisely the same form as Street's *C. Couesi*.

The following description of the living colors of *C. virilis* is given by Dr. Streets from the notes of Dr. Coues on the specimens collected in the Souris River, Dakota: —

"Carapace variegated with lighter and darker shades of brown: tail segment darker and more uniform brown, with large, symmetrical, dark brown spots, one on each side. Claws green, speckled with darker, with the protuberances yellow and reddish; other legs paler greenish. Below, including under side of the claws, greenish white, the claws speckled with dark spots. Antennæ rich brown."

A large female specimen in the U. S. National Museum, collected by Mr. Edward Palmer in a pond near Bridgeport, Jackson Co., Ala., appears to

belong here. The rostrum is mutilated, however, and my identification may be erroneous.

A young female from Lebanon, Tenn., in the Museum of Comparative Zoölogy, also seems to belong to this species.

A dry female in the Museum of Comparative Zoölogy is labelled "Lake George, L. Agassiz"; and there are also three dry specimens labelled "Montreal? Mr. Hunt." Considering the ease with which labels of dry specimens get misplaced, it is hardly safe to give Lake George and Montreal as localities for this species until confirmed by further exploration.

C. virilis attains a very large size. I have seen a female specimen which measured very nearly $4\frac{1}{2}$ inches in length, and Bundy records a specimen from Jefferson, Wis., $6\frac{3}{4}$ inches from tip of rostrum to tip of telson.

In specimens from Laramie the lateral spines of the rostrum are obsolescent, and the rami of the male appendages are more strongly curved than in the typical form. In these respects the specimens approach *C. immunis*. A male, form II., from Ellis, Kansas, in the Peabody Academy of Science at Salem, has the areola reduced almost to a line in the middle, and the shortness of the carapace behind the cervical groove shows another approach to *C. immunis*.

In specimens from Irondale, Mo., the cephalothorax is more cylindrical than in the type form, the areola wider in the middle (2 mm. in a specimen 68 mm. long, whereas in a specimen of the same size of the typical form it is about 1 mm.), and the tubercles on the internal border of the hand and on the movable finger are less prominent and more heavily ciliated. The sides of the rostrum are nearly parallel, with small acute lateral teeth. The carpus has the additional inferior spine as in Hagen's variety A. But I see no difference of sufficient importance to be deemed of specific value.

C. virilis and *C. immunis* are two of the Western species of crayfish esteemed as food. They are sometimes sent to the New York market from Milwaukee and other Western cities, but the species commonly found in the Eastern markets is *C. affinis*.

41. Cambarus immunis.

Plate X. figs. 6 a, 6 a′ (first abdominal appendages of male, form II.).

Cambarus immunis, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 71, Pl. I. figs. 101, 102, Pl. III. fig. 160, Pl. VIII. fig. b, 1870. (Male, form I., and female.)
Cambarus immunis, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 639, 1874. (After Hagen. No description.)
Cambarus immunis, Forbes, Bull. Ill. Mus. Nat. Hist., No. I. pp. 4, 19, 1876. (Male, form II., and young.)
Cambarus immunis, Bundy, Proc. Acad. Nat. Sci. Phila., 1877, p. 171.
Cambarus signifer, Herrick, Tenth Ann. Rep. Geol. Nat. Hist. Surv. Minn., for the Year 1881, p. 253, 1882.
Cambarus immunis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 146, 1884.

Known Localities. — New York (Coll. L. A. Lee). Indiana: White River (Coll. Bost. Soc. Nat. Hist.); Fall Creek, Indianapolis (Coll. Peabody Acad. Sci.); Long Lake, Kendallville (Bundy). Illinois: Aux Plains (Coll. U. S. Nat. Mus.); Belleville; Lawn Ridge; Normal; Oquawka (Coll. O. P. Hay). Michigan: Detroit River, Detroit. Wisconsin: Milwaukee (Coll. U. S. Nat. Mus.). Minnesota: Richfield, Hennepin Co. Iowa: West Liberty. Missouri: St. Louis (Coll. P. R. Uhler). Kansas: Leavenworth (Coll. Acad. Nat. Sci. Phila.); Ellis (Coll. C. H. Gilbert). Wyoming: near Laramie (Coll. U. S. Nat. Mus.). Alabama: Huntsville. Mexico: Orizaba (Coll. U. S. Nat. Mus.).

Var. spinirostris.

Plate I. fig. 5.

Cambarus immunis, var. *spinirostris*, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 146, 1884.

Known Locality. — Obion Co., Tenn.

C. immunis is a very common species in Illinois, being especially frequent in the muddy ponds of the prairies. Mr. H. G. Hubbard has found it in muddy pools and ditches connected with the Detroit River, Michigan. According to Mr. Hubbard, it does not form burrows, but conceals itself among weeds.

The second form of the male was unknown to Hagen, and was first described by Forbes in December, 1876. The first pair of abdominal appendages are split for but a very short distance from the tip; the branches are thick, and neither of them is dilated, flattened, or channelled at the tip, as is the case in the first form. (See Pl. X. figs. 6 a, 6 a′.) The tufts of hair-like setæ on the inner side of the penultimate and antepenultimate segment of the second pair of legs, so characteristic of this species, are

much less developed in the females and second-form males than in first-form males. In some, especially young, specimens slight ante-apical teeth are present on the rostrum.

I am indebted to Mr. C. L. Herrick for three examples, two first-form males and one female, of his *C. signifer*. It does not differ specifically from Hagen's *C. immunis*. The antennal scale is a little broader than in the types from Illinois, and the anterior process of the epistoma is not so clearly truncated; the punctation of the carapace is more pronounced. These differences are no greater than we often find in the same species when specimens from widely separated localities are compared. The color, as given by Herrick, is "reddish (crimson) brown, not obviously figured; tail lighter; fin chestnut, marked with gray; chelæ bright crimson below; there are green markings on the body and legs, and some yellow below." In the female, the "abdomen is marked with chestnut bars on each segment above." "The young males have the chelæ greenish blue and mottled, while the coloration of the body is like the females." The figure of the antennal scale (fig. 7, b) in Herrick's paper is very incorrect.

The hand of this species figured by Hagen on Plate VIII. of his Monograph is not of the normal form, but belongs to the specimen from Huntsville, Ala., mentioned on page 72. Although this specimen is a first-form male, the tufts of cilia on the second pair of legs are hardly developed. The female from Beaufort, N. C., (M. C. Z., No. 3356,) doubtfully assigned to this species by Hagen, does not belong here. It is perhaps *C. Diogenes*.

I have seen a few specimens of *C. immunis* with the internal margin of the movable finger straight, without the excision at the base, but such cases are very rare.

In the typical form of *C. immunis* the margins of the rostrum are sinuate at the apex, without spines at the base of the acumen. In many of the well-grown second-form males and females from the Detroit River, small lateral spines are developed at the base of the acumen; and these specimens thus lead to a form from Obion Co., Tenn., (Coll. U. S. Nat. Mus.,) in which the lateral rostral spines are developed in all the examples examined (seven second-form males, nine females). The sides of the rostrum in some of these are nearly parallel as far as the lateral spines. Although these specimens are of moderate size, they show the marks of immaturity, the chelipeds being small, the chelæ narrow, with slender fingers. The inner finger is generally excised at the base, as in the typical form; the lateral

thoracic spine is better developed, the antennæ are longer (equal to the length of the body), and the tufts of cilia on the inner side of the second pair of legs are not developed. The anterior process of the epistoma is not notched or truncated. The male appendages and the annulus ventralis are as in the typical *C. immunis*. In the only old specimen (female, $4\frac{1}{4}$ inches long) the rostrum and epistoma are, unfortunately, mutilated, but the chelæ are broad, as in the typical form, and the second pair of legs show the ciliate tufts. I am disposed to consider the variations here as varietal rather than specific. The form may be called *Cambarus immunis*, var. *spinirostris*.

The only specimens I have seen from the State of New York are a pair, so labelled, in the collection of Prof. L. A. Lee. Two specimens in the U. S. National Museum, male, form II., and female, from Orizaba, Mexico, (Prof. Sumichrast,) do not differ to any extent from those inhabiting the United States.

42. Cambarus Mississippiensis.

Plate III. fig. 2, Plate X. figs. 4, 4′, 4 a, 4 a′.

Cambarus Mississippiensis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 123, 1884.

Male, form I. — Rostrum broad, twice as long as broad, subexcavated above, smooth, foveolate at base, margins raised, converging anteriorly, sinuate at apex; acumen short, triangular, acute, no lateral teeth. Post-orbital ridges sulcate on outer side, with short, blunt anterior spines. Carapace densely punctate, sides lightly granulate, front lateral border not angulated. Cervical groove sinuate, with small lateral and branchiostegian spines. Areola linear anteriorly to the middle, with a small anterior and a larger posterior triangular field. Length of areola equal to half the distance from tip of rostrum to cervical groove. Abdomen as long as the carapace. Terminal segment of the telson shorter than the basal segment, hind border slightly concave at the centre; basal segment bispinose on each side. Anterior angle of epistoma notched. Sternum between the legs densely ciliated. Antennal scale very broad, apical spine short. Third maxillipeds hairy without and beneath. Chelæ large, punctate, smooth below, margined without; inner margin of hand short, furnished with dentiform tubercles irregularly disposed in a double series; a little distance from these is another line of smaller ciliated tubercles on the upper surface of the hand on a line with the middle of the base of the movable finger. Fingers long, gaping at base, each with

a punctate impressed line parallel with inner margin, and furnished with rounded tubercles on inner margin. Movable finger tuberculate on outer margin. Outer finger bearded below at base. Carpus broad, obliquely truncate on the external side, punctate and tuberculate above, a strong median internal spine, two small spines near on the base and one at the anterior end near the articulation; multispinous beneath, the two anterior spines the largest. Meros smooth, two ante-apical spines obliquely placed on upper margin, lower face with blunt biserial spines. Second pair of legs with long setæ near the end on inner side, not tufted as in *C. immunis*. Third pair of legs hooked. First pair of abdominal appendages long, deeply bifid, rami recurved at tip, parallel, internal ramus subcylindrical, dilated and grooved at tip, external ramus a little longer than the internal, laterally flattened, ending in a slender, sharp point.

Male, form II. — Rostrum with small lateral teeth; hand smaller, with smaller tubercles; hooks on third legs smaller; third pair of abdominal appendages stouter, cleft for only a short distance from the tip, tips blunt, no articulation at the base in the one specimen examined.

Female. — Rostrum as in the second form of the male. Hand shorter and broader, annulus ventralis with a very deeply excavated fossa.

Measurements of male, form I. — Length, 73 mm. Length of rostrum, 9 mm. Breadth of rostrum at base, 5 mm. Length of areola, 11 mm. From tip of rostrum to cervical groove, 25 mm. Length of chela, 35 mm. Breadth of chela, 14 mm. Length of inner finger, 24 mm. Length of internal margin of hand, 11 mm.

Five specimens, one male, form I., one male, form II., and three females, were collected by Prof. O. P. Hay in Eastern Mississippi. Two of them are labelled "Macon, Miss."

Differs from *C. immunis* in its linear areola, flatter rostrum, differently shaped chela, and male appendages, the rami of which are longer and less strongly recurved. *C. Palmeri* differs from it in its quadrangular rostrum, which has a longer acumen and more prominent lateral spines, narrower and long-spined antennal scale, and longer areola; the rami of the male appendages (form II.) are a little longer and more widely separated. *C. Alabamensis* differs by its wide areola, toothed and carinated rostrum, etc.; *C. compressus*, by its laterally compressed carapace, wide areola, narrow carinated rostrum, etc.

43. Cambarus Palmeri.

Plate III, fig. 6, Plate X, figs. 5 a, 5 a'.

Cambarus Palmeri, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 124, 1884.

Male, form II. — Rostrum broad, subexcavated, margins nearly parallel from base to lateral spines, which are small and sharp; acumen long. Post-orbital ridge with sharp anterior spine. Carapace smooth and punctate above, granulate on sides, lateral spine of moderate size, anterior lateral border notched just below the sub-orbital angle, which is not prominent. Areola linear for a short distance anterior to the centre, with a small anterior and a larger posterior triangular field. The length of the areola is one half the distance from cervical groove to tip of rostrum. Abdomen as long as the cephalothorax. Proximal segment of telson bispinose on each side. Antennæ nearly as long as the body. Lamina a trifle longer than rostrum, broad, greatest width at the middle, thence tapering to the long spine at apex. Third maxillipeds hairy within and below. Anterior process of epistoma truncate at apex. Chela broad, depressed, smooth and punctate below, ciliate-punctate above, margined on the outer edge. Inner margin of hand short, with a double row of small ciliated tubercles. Fingers of moderate length, straight, corneous and incurved at tip, costate, punctate, and ciliate above. Movable finger with outer edge furnished with a double row of ciliated tubercles on basal half. Outer finger hairy below at base of inner side. Carpus tuberculate above, with a strong and acute internal median spine, and a minute one at the base; smooth below, with two prominent anterior spines. Third pair of legs hooked. First pair of abdominal appendages articulated near the base, long, stout, strongly curved, bifid for a short distance from tip, rami divergent, outer one the longer.

Female. — Annulus ventralis triangular, rounded anteriorly, posterior wall with a longitudinal sigmoid fissure. Sternum between fourth pair of legs smooth.

Length, 61 mm. Antennæ, 52 mm.

Twenty-five specimens of this species were collected for the U. S. National Museum by Mr. Edward Palmer, in a brook running into the eastern side of Red Foot Lake, near Idlewild Hotel, Obion Co., Tenn., May 30, 1882. The lot contains males of the second form and females. The rostrum, chelæ, and antennal scale are similar to those of *C. virilis*. It differs from that

species in its linear shorter areola and male appendages, which are more strongly curved, and formed more on the pattern of the same parts in *C. immunis*. In the latter species, however, these appendages are still more strongly curved, the areola is not linear in any part, the rostrum is more deeply excavated, longer, and (usually) toothless, the antennal scale is subtruncate at the end, and the hand different. Its closest relative is *C. Mississippiensis*. See description of that species, page 101.

Some of the specimens still show spots of dark color (purplish) on the chelæ, carpus, and branchial regions of the carapace. In a few specimens there is a very faint indication of a median carina on the rostrum.

44. Cambarus Alabamensis.

Plate IV. fig. 4, Plate X. figs. 3, 3', 3 a, 3 a'.

Cambarus Alabamensis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 125, 1884.

Male, form I. — Rostrum broad, punctate, subexcavated above at base, with a broad, rounded, slightly elevated median carina near the tip; sides subparallel, punctate, ciliate; acumen long, triangular, marginal spines slightly developed. Anterior spine of post-orbital ridge hardly developed. Carapace smooth, punctate, cervical groove sinuate, with minute lateral and branchiostegal spines; anterior margin notched at base of antennæ; areola wide, short (less than half as long as the distance from cervical groove to the lateral rostral spines), thickly punctate. Abdomen longer than the cephalothorax by the length of the terminal segment of telson. Telson rounded behind, basal segment bispinous. Epistoma triangular. Antennæ nearly as long as the body, slender; scale moderately broad, broadest in middle, thence tapering to the apical spine. Third maxillipeds hairy within and below. Chelipeds of moderate length, strong. Chela broad, thick; hand punctate, inner margin of moderate length, scarcely serrate; fingers of moderate length, costate, ciliate-punctate, usually meeting only through their distal third. Immovable finger heavily bearded at base within, both above and below. Carpus smooth, punctate above; on the internal border there is a strong median spine; in front of this, near the articulation, is a minute spine, and behind it are one or two faint ones near the base; below, the carpus has a single small spine near the external articular point of the hand. Meros smooth, punctate, with two obliquely disposed spines near the anterior end of superior border; of the biserial spines beneath, only the distal one or two

of the outer row are developed. Third pair of legs hooked at base. First pair of abdominal appendages long, deeply bifid, rami slender, recurved, parallel, inner ramus spoon-shaped at tip, outer ramus a little longer than the inner, compressed laterally, tapering to a fine point at tip.

Male, form II. — Lateral rostral spines a little more prominent, hand smaller, hooks on third legs less strongly developed, first abdominal appendages thicker, bifid for only a short distance from the tip, rami laterally compressed, blunt-pointed.

Female — Rostrum as in the second form of the male, hand shorter and wider. Annulus ventralis with well-marked transverse fossa.

Measurements of a male, form I. — Length, 55 mm. Carapace, 25 mm. Abdomen, 30 mm. Length of antennæ, 50 mm. Length of areola, 7 mm. Breadth of areola, 2.5 mm. Length of chela, 21 mm. Breadth of chela, 9 mm. Length of movable finger, 12.5 mm.

A female of the same size has the areola 3 mm. in width, 7 mm. in length.

Forty specimens, including both forms of the male and the female, were collected by C. L. Herrick in Second Creek, Waterloo, Lauderdale Co., Ala., for the U. S. National Museum. The male appendages are very like those of *C. Mississippiensis*, the rami being longer and less strongly recurved than in *C. immunis*. It is at once distinguished by its broad and short areola from the other species in which the first abdominal appendages are formed after the pattern of those of *C. immunis*. The section of the carapace behind the cervical groove is very short in this species, and the dense beard at base of the external finger is very characteristic. In *C. compressus* the areola, although broad, is long, and the strong lateral compression of the body, different form of the chela, etc., distinguish it from this species at a glance.

45. Cambarus compressus.

Plate V, fig. 6, Plate X. figs. 2, 2′, 2 a, 2 a′.

Cambarus compressus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 127, 1884.

Male, form I. — Rostrum narrow, excavated, curved downwards, with a longitudinal median carina; margins thickened, converging, with a line of ciliated dots; acumen long, triangular, with acute lateral spines at base which are obsolescent in the largest specimens. Cephalothorax strongly compressed laterally. Post-orbital ridges armed with acute anterior spines.

Carapace punctate on both the back and sides; on the gastric region the punctation is very coarse, assuming the form of reticulation; cervical groove sinuate; no lateral or branchiostegian spines; anterior lateral margins notched behind the antennæ; areola broad, heavily punctated. Abdomen about the length of the thorax. Telson long, proximal segment bispinose on each side. Antennæ slender, shorter than the body by the length of the telson. Antennal scale of moderate width, terminal spine very long, reaching beyond the tip of the rostrum. Epistoma triangular. External maxillipeds hairy within and below. Chelipeds short, stout; chelæ very large, broad, non-tuberculate, hand convex above and below, punctate, internal margin entire; fingers short, thick, with lines of ciliated dots. Carpus punctate above, with one internal median spine. Upper border of meros with one or two ante-apical spines; the biserial spines below are not developed, except the distal one of each row, and even these are minute. Third segment of third pair of legs hooked. First pair of abdominal appendages reach the base of the second pair of legs. They are deeply bifid, the rami recurved; the outer ramus is aciculate, the inner is enlarged at base and at tip, and the tip is furthermore grooved in front and rounded off at the end.

Male, form II. — Hand smaller, fingers gaping at base, external finger ciliated at base within, hook on third segment of third legs very small; first pair of abdominal appendages articulated near the base, thick, inner and outer parts separated for only a very small distance from apex, compressed from side to side, tips a little recurved, blunt-pointed.

Female. — Chelæ somewhat smaller than in the first form of the male, fingers less widely separated at base, external finger ciliated at base within. Anterior border of annulus ventralis nearly obliterated in the median line, lateral borders raised into prominent tubercles, transverse fossa wide.

Length of body (male, form I.), 45 mm. Length of carapace, 22.5 mm. Length of areola, 8 mm. Breadth of areola, 2 mm.

In the largest specimen seen, the dimensions of which are given above, the lateral spines of the rostrum are obsolete, the margins simply notched at base of the acumen; in the other specimens the lateral rostral spines, though small, are evident; the antennæ in the larger specimens are shorter in proportion to the length of the body.

Thirty-nine specimens (eighteen males, form I., two males, form II., and nineteen females) were collected by C. L. Herrick, for the U. S. National Museum, in Second Creek, Waterloo, and in Cypress Creek, Lauderdale Co., Ala., October, 1882.

A small species, with first abdominal appendages of the male similar to those of *C. immunis*. It is readily distinguished from all the other species with similar male appendages by the lateral compression of the cephalothorax, form of the chela, etc.

46. Cambarus medius.

Plate III. fig. 4, Plate IX. figs. 4, 4'.

Cambarus medius, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 121, 1884.

Male, form I. — Rostrum of moderate length, excavated, slightly carinated at the tip; margins thickened, converging, sinuated near the tip to form the short triangular acumen; no lateral spines. Post-orbital ridges depressed, sulcated on external face, subacute anteriorly. Carapace subcylindrical, somewhat flattened above, punctate, granulated on the sides; cervical groove sinuate, no lateral or branchiostegian spine; sub-orbital angle rounded; areola long (much more than half as long as the distance from the cervical groove to the tip of the rostrum), of moderate width, punctate, widening posteriorly. Abdomen as long as the cephalothorax; telson rounded behind, basal segment bispinous on each side of the posterior border. Basal segment of antennule with an interior median spine. Second and third segments of antennæ not spiniferous (flagellum of antennæ broken off in the specimen examined, probably much shorter than the body). Antennal scale short, of moderate width, terminating in a short, acute spine. Anterior process of epistoma triangular, apex pointed, sides convex. Third maxillipeds bearded within. Chelipeds of moderate length, stout; chela broad, inflated, coarsely punctate above and below, external margin rounded; internal margin of hand with a double row of obsolescent tubercles; fingers stout, gaping at base, costate, heavily dotted-lined, internal margins furnished with rounded tubercles. Carpus sparsely punctate, armed with a moderate median and a smaller basal internal spine; below, there are no spines developed. Meros furnished with two nearly obsolete obliquely placed tubercles near the distal extremity of superior border, and with a double row of tubercles below. Second pair of legs provided with long cilia towards their distal extremity. Third segment of third pair of legs hooked. First pair of abdominal legs long (reaching to base of chelipeds), deeply bifid, rami slender, straight, the outer one a little recurved at the tip, aciculate, the inner one slightly dilated near the tip, blunt pointed; a projecting angle or shoulder at base of rami on anterior margin.

Female. — Hand small, fingers not gaping, ciliated within; sternum between fourth pair of legs plane; annulus ventralis bilaterally symmetrical, anterior border bituberculate, posterior border unituberculate, transverse fossa deep, recurved at each end.

Measurements of male, form I. — Length of body, 49 mm. Length of carapace, 25 mm. Length of rostrum, 6 mm. Length from end of rostrum to cervical groove, 15.5 mm. Length from cervical groove to hind border of carapace, 9.5 mm. Width of areola, 2 mm. Length of abdomen, 25 mm. Length of chela, 23.5 mm. Length of internal margin of hand, 9.5 mm. Breadth of chela, 11.5 mm. Length of movable finger, 14 mm.

Two specimens, first form of male and female, in the Museum of Comparative Zoölogy, from Irondale, Mo.

This species has the general form of body, rostrum, and chelæ of the *C. Bartonii* group, together with the male abdominal appendages of the *C. affinis* group. These appendages have a projecting shoulder at the base of the rami, on the anterior edge, as in *C. rusticus*, *C. Putnami*, etc. *C. immunis* and *C. Mississippiensis*, belonging to the *C. affinis* group, also have the rostrum devoid of lateral spines, but in general habit of body they do not resemble *C. Bartonii* and its allies, as is the case with the present species.

47. Cambarus rusticus.

Plate IX. figs. 8, 8′, 8 a, 8 a′ (first abdominal appendages of male).

Cambarus rusticus, Girard, Proc. Acad. Nat. Sci. Phila., VI. 88, 1852.
Cambarus rusticus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 71, Pl. I. figs. 80–83, Pl. III. fig. 161, 1870.
Cambarus placidus, Hagen, op. cit., p. 65, Pl. I. figs. 76-79, Pl. III. fig. 158, 1870.
Cambarus juvenilis, Hagen, op. cit. p. 66, Pl. I. figs. 29–33, Pl. III. fig. 157, 1870.
Cambarus rusticus, Smith, Rep. U. S. Comm. Fish and Fisheries for 1872 and 1873, p. 639, 1874. (After Hagen. No description.)
Cambarus placidus, Smith, op. cit.. p. 638, 1874. (After Hagen. No description.)
Cambarus juvenilis, Smith, op. cit., p. 38, 1874. (After Hagen. No description.)
Cambarus Wisconsinensis, Bundy, Bull Ill. Mus. Nat Hist., No. I. p. 4, 1876. — Trans. Wis. Acad. Sci., V. 181, 1882. — Geol Wis., Surv. 1873–1879, I. 402, 1883.
Cambarus placidus, Forbes, Bull. Ill. Mus. Nat. Hist., No. I. pp. 4, 19, 1876. (After Hagen.)
Cambarus Wisconsinensis, Forbes, op. cit., p. 19. (After Bundy.)
Cambarus rusticus, Bundy, Trans. Wis. Acad. Sci., V. 181, 1882. — Geol. Wis., Surv. 1873–1879, I. 402, 1883. (Not described.)
Cambarus placidus, Bundy, Trans. Wis. Acad. Sci., V. 181, 1882. (Not described.)
Cambarus rusticus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 148, 1884.

Male, form I. — Rostrum long, narrow, concave on the sides, excavated, margins thickened, dotted-lined, divergent at the base; acumen of moderate

length, triangular, with acute, upturned, brown, horny terminal spine; marginal spines short, upturned, fusco-corneous. Carapace flattened above, punctate, lightly granulate on the sides, lateral spine small, often obsolete, branchiostegian spine obsolete; post-orbital ridges terminating anteriorly in a very short spine, which is sometimes obsolete in large specimens; antero-lateral border very slightly angulated behind the antennæ; areola equal in length to the distance from the cervical groove to the base of the rostrum, narrow, irregularly punctate, sides subparallel for the greater part of its length, divergent at the fore and hind ends. Abdomen a little shorter than the cephalothorax; posterior border of telson rounded, posterior margin of basal segment bispinose on each side. Basal segment of antennule armed with an interior spine near the apex of lower side. Antennæ about as long as the body, spine on external margin of second segment small or obsolete; scale broad, a trifle longer than the rostrum, widest beyond the middle, thence tapering to the short, acute, horny-tipped, external apical spine. Third maxillipeds hairy within, nearly naked below. Anterior process of epistoma triangular, antero-lateral borders convex, lateral angles prominent, apex usually blunt. Chela large, punctate; internal border of hand furnished with a double row of low depressed tubercles; fingers ornamented with lines of dots, of moderate length (the movable finger not much more than twice the length of internal margin of the hand); fingers gaping at the base, not bearded, movable finger incurved, external margin concave, with obsolescent tuberculation like that on the inner margin of the hand; external finger incurved, external margin convex; inner margins of both fingers furnished with rounded tubercles. Carpus broad, coarsely punctate above, internal median spine small, in some examples obsolescent, inferior median and external spines small or obsolete; meros smooth on the external face, with two small, obliquely placed superior sub-apical spines, one or both of which may be obsolete, inferior biserial spines usually but slightly developed, except the apical one of each row. Third segment of third pair of legs hooked. First pair of abdominal appendages, when turned forward, reach the base of second pair of legs; they are deeply bifid, the rami slender, styliform, shorter than the proximal undivided part; outer ramus straight, or arcuate (the concave side being posterior), subulate; inner ramus a little shorter than outer, straight or arcuate, a little incurved at the apex, tip aciculate, or in old specimens dilated; a projecting angle or shoulder on the anterior margin at base of the rami.

Male, form II. — Hooks of third pair of legs smaller; first pair of abdominal appendages thicker, bifid for but a short distance from the tip, rami stout, the outer one the longer, the inner one slightly incurved, swollen at tip, blunt pointed; very slight trace, or none, of projecting angle on anterior margin at base of the rami.

Female. — Sternum between the fourth pair of legs smooth; anterior wall of annulus ventralis largely developed, bituberculate, fossa triangular, posterior wall with a median, backward-projecting tubercle divided by a longitudinal narrow fissure.

Length of a male, form II., 73 mm. Length of carapace, 36.5 mm. Length of abdomen, 36.5 mm. Length of rostrum, 8.5 mm. From tip of rostrum to cervical groove, 22.5 mm. From cervical groove to hind margin of carapace, 14 mm. Width of areola, 1.5 mm.

Known Localities. — Pennsylvania: Pittsburg (Coll. Acad. Nat. Sci. Phila.); Philadelphia Co. [?] (Coll. Acad. Nat. Sci. Phila.). Ohio: Kelley's Island, Lake Erie (Peabody Acad. Sci.); Miami River, Dayton (Coll. Acad. Nat. Sci. Phila.); Yellow Springs; Cincinnati, Ohio River. Indiana: Madison, Ohio River (Coll. O. P. Hay); White River (Coll. Bost. Soc. Nat. Hist.); Indianapolis (Coll. Peabody Acad. Sci.). Illinois: Quincy; Normal (W. F. Bundy). Kentucky: Little Hickman, Kentucky River; Perryville, Boyle Co.; Salt River. Tennessee: Cumberland Gap; Lebanon. Lake Superior. Wisconsin: Racine; Beloit (W. F. Bundy); Ironton (W. F. Bundy); Fox River (W. F. Bundy [*C. placidus*]). Iowa: Lizard Creek, Fort Dodge. Missouri: Osage River. Arkansas: White River, Eureka Springs, Carroll Co. (Coll. U. S. Nat. Mus.). Texas.

The above description is drawn up from Hagen's types of *C. rusticus* from Cincinnati, Ohio (M. C. Z., No. 285), and from specimens of the same form from Yellow Springs, Ohio (M. C. Z., No. 3427). Hagen's type from Lake Superior (M. C. Z., No. 187) differs in having very long, straight fingers, not tuberculate on their inner margins, like *C. placidus* Hag.

In the larger males, form I., from Yellow Springs, the rami of the first abdominal appendages are curved forwards a little at the base, and then recurved toward the tip, forming an arc; the tip of the inner rami is considerably dilated. In very young specimens of both sexes (20 mm. long, or thereabouts) there is a dense beard on the interior margin of the carpus and meros of the chelipeds, as well as on the inner side of the external finger near the base. In some specimens the fingers are long and straight.

Girard's description of *C. rusticus* is as follows: —

"Rostrum narrower than in both *C. affinis* and *C. Pealei*, and, besides, concave on the sides. Terminal point shorter than either of the preceding species [*C. pellucidus*, *affinis*, *Oreganus*, and *Pealei*]; anterior pair of abdominal legs (in the male) elongated, slender, with their tip curved inwards, whilst the same tips are straight in *C. affinis*, and twisted in *C. pellucidus*. The dorsal area is broader than in *C. Pealei*.

"Locality. — The Ohio, at Cincinnati."

This description does not fit very well, but Dr. Hagen examined one of Girard's types and ascertained its identity.

Closely related to the above described form are Hagen's *C. placidus* and *C. juvenilis*. I find so many specimens among the material at my disposal which combine characters of these three, that I am led to consider them all as varieties or forms of *C. rusticus*.

In the type (male, form I.) of *C. placidus*, from Quincy, Ill. (M. C. Z., No. 296), the rostrum is longer and narrower than in the typical *C. rusticus*, with longer acumen and lateral spines; the hands have long, straight, non-tuberculate fingers, like the *C. rusticus* from Lake Superior mentioned above; the rami of the first pair of abdominal appendages are a little recurved, and want the projecting shoulder at the base of the rami on the anterior border; the antennal scale is subtruncate, with longer apical spine. The types from Lebanon, Tenn. (M. C. Z., No. 289), are second-form males and females. They differ from the Quincy specimen in having a well-developed internal median spine on the carpus, and an acute though small lateral spine on the carapace; in some of these specimens the rostrum is slightly carinated near the tip; the external ramus of the first abdominal appendage, instead of being straight, as in the typical *C. rusticus*, is a little recurved at the tip. Of the types from Texas (M. C. Z., No. 170) there are now five in the Museum collection, four males of the first form, one male of the second form. In three of the first forms a projecting shoulder is prominently developed on the anterior border of the first pair of abdominal appendages, as in *C. rusticus* and *C. juvenilis;* in the fourth specimen it is also present, but less marked. Two or three of these examples further agree with the typical *C. rusticus* in the form of the chela. The internal median carpal spine is strongly developed, the lateral spine of the carapace small and acute, the inner row of inferior spines of the meros well pronounced. The first pair of abdominal appendages in all the first-form male types of *C. placidus* are a little longer than in *C. rusticus*.

The types of *C. juvenilis* from Little Hickman, Ky. (M. C. Z., Nos. 213, 3347) differ from the types of *C. rusticus* in the following respects. The first pair of abdominal appendages are longer, reaching forwards as far as the base of the chelipeds when the abdomen is flexed; the rami are slenderer, longer, and set at a slight angle with the basal part of the appendage; the inner ramus is straight, parallel with the outer ramus (not twisted), pointed at the tip, not dilated. The margins of the rostrum are more thickened. The punctation of the carapace is finer. The areola is narrower, the narrowest part being in front of the centre, thence widening posteriorly; it follows that the sides of the areola are not parallel for any distance, whereas in *C. rusticus* the sides of the areola, after converging to the posterior end of the anterior triangular field, run nearly parallel to one another for some distance, diverging towards the posterior end of the carapace to form the hinder triangular areolar field. The hand is short, with long fingers which meet throughout their entire length; the external finger is barbate within at base. In the male of the second form the tip of the outer ramus of the first abdominal appendages is slightly recurved.

There is, however, some variation among these types. In one male of the first form the fingers are of moderate length, slightly gaping at the base, the inner carpal spine small but acute; the areola is of the form seen in *C. rusticus*.

Two female specimens from Cumberland Gap, Ky. (M. C. Z., No. 3580) agree with the types of *C. juvenilis* from Little Hickman.

Hagen's type of *C. juvenilis* from the Osage River (M. C. Z., No. 271) differs from the Kentucky types, and agrees with the specimens from the Osage River (M. C. Z., No. 3446) mentioned farther on.

Among specimens received from Perryville, Ky. (M. C. Z., Nos. 3442, 3443) and Salt River, Ky. (M. C. Z., No. 3578), which agree in most respects with Hagen's types of *C. rusticus*, many have an inflated hand, with very convex external border and rather short fingers. The carapace is flattened on the back. In many respects these specimens resemble *C. juvenilis;* and if *C. juvenilis* and *C. rusticus* be separated as two distinct species, it is hard to say to which species these specimens should be assigned.

Specimens from Cumberland Gap, Ky., males of the first form (M. C. Z., No. 3444), have the rami of the first pair of abdominal appendages long and slender, as in *C. juvenilis;* when the abdomen is flexed, these appendages reach forward to the base of the chelipeds. The internal median

and the inferior median anterior spines of the carpus are well developed; of the spines of the meros, the superior apical and the external row of the inferior biserial ones are developed; only one or two of the distal ones of the inner row are present. In one specimen the fingers are much elongated. There is a dark ring around the fingers near the tip. The carapace is flattened above, densely and coarsely punctate, lateral spines small, acute; areola as wide as in the typical *C. rusticus*, and of a similar form. A closely similar form comes from Lizard Creek, Fort Dodge, Iowa (M. C. Z., No. 3554).

In small specimens, 52 mm. long, males of the second form and females, from Southern Indiana (M. C. Z., No. 3553), the lateral spine of the carapace, the anterior spine of the post-orbital ridge, and the spine of the carpus and meros, are acute and well formed, though small. The rostrum is excavated, and thickened on the margins, as in the typical *C. rusticus*.

A type, male form II., of *C. Wisconsinensis* Bundy, from Racine, Wis., received from Dr. Bundy (M. C. Z., No. 3448), agrees in most particulars with *C. placidus* Hagen. The rostrum is shorter, and the internal part of the first abdominal appendages is swollen near the tip, as in Hagen's *C. rusticus*. The anterior process of the epistoma is not truncate or emarginate. The interior median and inferior median carpal spines are well developed.

In the same jar with *C. virilis* from the Osage River (M. C. Z., No. 169) I find many small specimens, males of the second form and females, which agree very closely with the types of *C. placidus* from Lebanon, Tenn., and from Texas. With these goes a single first-form male from the same locality (Osage River), determined by Hagen as *C. juvenilis* (M. C. Z., No. 271). The largest of these specimens (a female) is 71 mm. long. The rostrum and antennal scale are as in *C. placidus*, the fingers of moderate length, the internal median carpal spine well developed, the inferior median carpal spine small and acute (in the first-form male obsolescent), the areola narrow. The first abdominal appendages of the first form of the male have a prominent angle on the anterior border, the inner ramus is straight, dilated at the tip, the outer ramus is a little recurved; in the second form of the male the inner ramus is straight, the outer slightly recurved at the tip. The inner side of the base of the external finger is bearded in the female and second-form male, naked in the first-form male. Differs from *C. Putnami* in having a narrower, more excavated rostrum, narrower areola, and shorter male appendages.

In the collections of the Peabody Academy of Science, the Boston Society of Natural History, and Bowdoin College, there are many young speci-

mens, second-form males and females, from Bradford, Ind., collected by A. S. Packard, Jr., labelled (apparently in Dr. Packard's hand) "*Cambarus spinosus* Bundy," in one case "*Cambarus spinosus* Bundy, *fide* Bundy." They are certainly not *C. spinosus*, which is a Southern species with a short areola. I think they are young *C. rusticus*, some of them possibly *C. Putnami*. The areola is rather broad for *C. rusticus*, and the male appendages are rather short for *C. Putnami*. In some of these specimens the rostrum is broad and nearly plane (in this resembling *C. obscurus*), and even a little carinated near the tip. The tips of the fingers are orange-color preceded by a dark ring.

All the forms mentioned above agree in having an excavated rostrum with thickened margins, a long and narrow areola, the first pair of abdominal appendages of the first-form male furnished with a projecting angle on the anterior margin at base of rami (except in the *C. placidus* from Quincy, Ill., in which this angle is obsolete), the rami long and straight or the outer one somewhat recurved. The chelæ have a double row of low, inconspicuous tubercles on their inner margin. They vary somewhat in the width of the rostrum and areola, in the development of the spines of the rostrum, carapace, carpus, and meros, in the length and curve of the fingers, and in the length of the rami of the first abdominal appendages. After a careful comparison of all the specimens before me, I am inclined to unite them all as forms of *C. rusticus*.

In the collection of the Academy of Natural Sciences of Philadelphia are five dry specimens of this species (Nos. 126[a], 126[c]), which, according to the labels, came from the State of Pennsylvania. Two of these are labelled by Dr. Hagen "*C. placidus*." Three (126[a], 126[c], Philadelphia Co. and Pittsburg) are in the same box together, labelled "*A. Bartonii*" by Gibbes, "*C. affinis*" by Hagen; and on pages 62 and 78 of his Monograph Dr. Hagen says that the types of *A. Bartonii* Gibbes in the Philadelphia Academy are *C. affinis* Say. When I examined the Philadelphia collection in December, 1882, they seemed to me surely *C. placidus* Hagen. No. 126[b] in the same collection, labelled "*C. affinis* Say (*C. Bartonii* Gibbes)," is the true *C. Bartonii*, from Delaware. There is little chance that transposition of labels has taken place, as the number is pasted upon the specimens, and Gibbes's label and the original locality label bear the same number.

48. Cambarus spinosus.

Plate IX. figs. 7, 7′, 7 a, 7 a′ (first abdominal appendages of male).

Cambarus spinosus, Bundy, Proc. Acad. Nat. Sci. Phila., 1877, p. 173.
Cambarus spinosus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 148, 1884.

Male, form II. — Rostrum broad, excavated, the raised margins parallel and continued back on the carapace between the post-orbital ridges, an impressed ciliated line on each margin; acumen long, acute, with well-developed lateral teeth at base. Post-orbital ridges sulcate without, with short anterior spines. Carapace ovoid, smooth and punctate above, lightly granulated and ciliated on the sides, lateral spines single, long, acute; cervical groove not sinuous; small branchiostegian spines; front border of carapace a little angulated behind the antennæ; areola moderately wide, of equal width before and behind, punctate, equal in length to half the distance from cervical groove to lateral rostral spines. Abdomen equal to the cephalothorax in length, mostly smooth, proximal segment of telson bispinose on each side. Epistoma wide, emarginate in front. Antennæ long (as long as the body or longer); scale as long as the rostrum, narrow, widest in the middle, thence tapering gradually to the long, sharp, apical tooth; external border inflated, turned outward at the distal end. Third pair of maxillipeds hairy without, naked below. Chela of moderate size, punctate above, smooth below, a double row of ciliated tubercles on the inner border of the hand; fingers of moderate length, slightly gaping at base, costate and ciliate-punctate, toothed and ciliate on inner border; outer margin of movable finger with two or three rows of tubercles. Carpus tuberculate above, internal border with a large, curved, sharp median spine, and a small anterior and posterior spine; below there is a large median spine on anterior margin, and a smaller one at the point of articulation with the hand. Meros with two obliquely disposed spines near the distal end of superior border; the outer row of the biserial spines beneath consists of the two distal spines alone. Third pair of legs hooked. Anterior pair of abdominal appendages very long, reaching forward to the base of the large claws, deeply bifid, rami slender, blunt-pointed, outer ramus longer than the inner, a little recurved at the tip.

Male, form I. — According to Bundy, the hooks on the third legs are larger; first pair of abdominal appendages "strongly bifid, tips of equal length, very slender, straight, separating at node; anterior margin with a

tooth or projecting angle about midway from base to extremities; apical forming a very obtuse angle with basal half."

Female. — Fingers shorter than in the male; annulus ventralis with a large tubercle on the posterior margin divided in the middle by a longitudinal sinuous line, anterior border bituberculate, fossa deep, transverse.

Measurements of a male, form II. — Length, 70 mm. Cephalothorax, 35 mm. Abdomen, 35 mm. From tip of rostrum to cervical groove, 24 mm. From cervical groove to posterior border of telson, 10 mm. Length of rostrum, 11 mm. Width of rostrum, 4.5 mm. Length of acumen of rostrum, 5 mm.

Known Localities. — South Carolina: Saluda River (Coll. Butler Univ.). Georgia: neighborhood of Rome (Etowah, Oostenaula, and Coosa Rivers). Tennessee River near border of Georgia. Alabama: Cypress Creek, Lauderdale Co.

The specimens described by Bundy were collected in the neighborhood of Rome, Ga., by Prof. D. S. Jordan. Some of these specimens have been communicated to me by Prof. O. P. Hay, of Butler University, Irvington, Ind., and Mr. P. R. Uhler, of Baltimore, Md. They embrace males of the second form, females, and young. According to Bundy, only one out of the nineteen specimens examined by him was a male of the first form.

In general appearance this species resembles *C. affinis*, but differs in being smoother, in the shortness of the carapace behind the cervical groove, the single lateral spine, the absence of spines on the hepatic region, emarginate epistoma, longer antennæ, and in the form of the male appendages, which resemble those of *C. rusticus* and *C. obscurus*. In these, however, the male appendages are shorter, and the rami are shorter relatively to the length of the whole appendage.

The female specimen from the Tennessee River near the borders of Georgia, mentioned by Hagen under *C. extraneus* as resembling *C. affinis*, belongs to this species. Jordan also found *C. spinosus* in company with *C. extraneus* in the rivers explored by him in the neighborhood of Rome, Georgia.

In the collection of Butler University is a single female *C. spinosus*, collected by Jordan in the Saluda River, South Carolina. In this specimen the posterior section of the carapace is a little longer than in the Georgian types, the distance from the cervical groove to the posterior border of the carapace being equal to half the distance from the groove to the middle of the

acumen of the rostrum, and the anterior process of the epistoma is longer and not emarginate.

Before this species was well known, the female might easily have been confounded with *C. affinis*. I suspect that the female specimen from Greenville, South Carolina, in the Berlin Museum, referred to *C. affinis* by Erichson, belongs here.

The Saluda River specimen is the largest seen by me. It measures $3\frac{1}{2}$ inches in length. Bundy gives the length of the largest examined by him as $3\frac{3}{4}$ inches.

Specimens collected for the U. S. National Museum in Lauderdale Co., Alabama, by C. L. Herrick, agree in most respects with the specimens from Georgia, but differ as follows. The lateral margins of the rostrum, instead of being very nearly parallel from the base to the lateral spines, converge very perceptibly from the base to midway between the base and the lateral spines; the epistoma is longer, but emarginate in full-grown specimens, like the type form; the carapace is more heavily punctate. I am inclined to regard it as a variety of *C. spinosus*.

Among these specimens from Lauderdale Co. is the first form of the male, in which the hand is broader and shorter-fingered than in the second form, and the hooks on third legs larger; the first abdominal appendages (Pl. IX. figs. 7, 7′) agree pretty well with Bundy's description of these parts in *C. spinosus*, but the outer ramus is a little longer than the inner. The shoulder at the base of the rami, on the anterior border, is very prominent; the inner ramus is thicker than the outer, lanceolate at the tip, the outer aculeate at the tip. The rami form a hardly perceptible angle with the basal part of the appendage. The coloration of these specimens agrees with Bundy's description of the color markings of *C. spinosus*. The fingers have a dark band near their tips, the tips being orange; outer margin of outer finger with a dark stripe continued on the outer margin of the hand to the carpus; two or three dark spots on the hand at the base of the movable finger. Until I have seen the first form of the male of *C. spinosus* from Georgia, I cannot be positive of its specific identity with the Alabama specimens.

49. Cambarus Putnami.

Plate V. fig. 5, Plate IX. figs. 6, 6′, 6 a, 6 a′.

Cambarus Putnami, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 131, 1884.

Male, form I. — Rostrum broad, subexcavated, margins nearly parallel, with a line of ciliated puncta; acumen long, equal in length to the width of base of rostrum, narrow, acute, with a black horny tip and lateral spines. Post-orbital ridges sulcate on external side, inflated at posterior end, armed with a sharp, horny-tipped anterior spine. Carapace long-oval, slightly flattened above, heavily punctated, sides rough with ciliated granules; cervical groove deep, lightly sinuate, broken on the sides just above the small, acute lateral spine; branchiostegian spine slightly developed; anterior lateral margins angulated, but without sub-orbital spine. Posterior segment of carapace equal in length to half the distance from tip of rostrum to cervical groove. Areola of moderate width, punctated. Abdomen as long as cephalothorax, pleura punctate, telson bispinose on each side. Anterior process of epistoma ciliated, triangular, sides convex, marginate. Basal segment of antennule armed below with an internal ante-apical spine. Antennæ slender, about as long as the body, scale as long as the rostrum, of moderate width, external border inflated, ending in a sharp spine. Third maxillipeds hairy within and below. Chelipeds stout; chela large, external margin convex; hand ciliate and punctate above and below (the dots large), swollen above, internal border of moderate length and furnished with two or three rows of depressed ciliated tubercles; fingers gaping at base, at least in large individuals, costate and punctate-lined, external margin of movable finger with depressed ciliated tubercles irregularly disposed in two rows; tips of fingers incurved, horny. Carpus smooth or faintly tuberculate above; a large, acute median internal spine, and small proximal and distal internal spines; beneath, the carpus has a very minute or no median anterior spine, a short and acute external spine. Meros with two superior obliquely placed ante-apical spines; of the ordinary biserial inferior spines only the distal one or two of the outer row are developed. Third pair of legs hooked on third segment. Thoracic sterna hairy. First pair of abdominal appendages very long, reaching the base of the chelipeds when the abdomen is flexed, tuberculated on internal border at the base, deeply bifid; rami slender, acute, forming an acute angle with the basal part, the outer slightly recurved, the

inner shorter, incurved, and a little dilated before the tip; a projecting angle or shoulder on the anterior border at base of rami.

Male, form II. — Chela smaller, fingers not gaping, hook on third segment of third pair of legs smaller; first pair of abdominal appendages split only half as far down as in the first form, rami much thicker, no projecting angle on the anterior border; these appendages are as long as in the first form, reaching forward to the base of the chelipeds; they are articulated near the base.

Female. — Chela shorter and wider, external finger bearded within at base; sternum between fourth pair of legs non-tuberculate, lightly ciliate. Annulus ventralis large, transverse fossa broad and deep, anterior border bituberculate.

Measurements of a male, form I. — Length of body, 73 mm. Length of carapace, 36 mm. From tip of rostrum to cervical groove, 24 mm. From cervical groove to hind border of carapace, 12 mm. Length of rostrum, 11 mm. Breadth of rostrum at base, 4.5 mm. Length of acumen of rostrum, 4 mm. Width of areola, 2.5 mm. Length of abdomen, 37 mm. Length of chela, 34 mm. Breadth of chela, 14 mm. Length of movable finger, 22 mm.

Known Localities. — Kentucky: Grayson Springs, Grayson Co.; Green River, near Mammoth Cave; Cumberland Gap.

M. C. Z., No. 3574 (young female), from Knoxville, Tenn., Walter Faxon, and No. 3575 (male, form II.), from Bradford, Ind., A. S. Packard, Jr., probably belong to this species, but the specimens are too young to determine with confidence.

This species resembles *C. spinosus*, from which it is easily distinguished by the length of the posterior section of the carapace, and by the length of the male appendages. From *C. affinis* it may be separated by the different form of the male appendages and female annulus ventralis, and by the single lateral spine of the carapace. I have seen males of the first form only 34 mm. in length.

50. Cambarus forceps.

Plate V. fig. 4, Plate IX. figs. 5, 5′, 5 a, 5 a′.

Cambarus forceps, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 133, 1884.

Male, form I. — Rostrum narrow, excavated, faintly carinated in the middle; margins divergent at the base, thickened, dotted-lined; acumen long

and narrow, horny-tipped; lateral spines small. Post-orbital ridges not very prominent except anteriorly, where they terminate in a spine with a corneous tip. Carapace cylindroidal, punctate above, granulated on the sides, antero-lateral margins bluntly angulated; cervical groove sinuate; small and acute lateral spine; no branchiostegian spine; areola of moderate width, punctate. Abdomen as long as the cephalothorax; telson rounded behind, bispinose on each side. Epistoma smooth, anterior process triangular, in some specimens truncate. Thoracic sterna with silky setæ at bases of the legs. Antennæ slender, as long as the body; scale a little longer than the rostrum, of moderate width, subtruncate at distal end, outer margin ending in a long, sharp, somewhat outwardly directed spine. Third pair of maxillipeds hairy within. Chelipeds short, stout; chelæ large, wide, with slender cylindrical, widely gaping fingers, which are curved outward at the base and opposable only at their tips; hand thickly punctated above and below, inner margin obscurely serrate; fingers naked at base, with parallel rows of ciliated dots; a dark band around both the inner and outer fingers a little distance from the tip. Carpus punctate above, with a strong, sharp internal median spine; below there is no anterior median spine, and only a very minute external one. Meros short; of the biserial inferior spines only the distal one in each row is usually developed to any extent; above there are commonly two obliquely placed ante-apical spines, in some specimens only one. Distal portion of the following pairs of legs furnished with long setæ, especially long on the second pair of legs. Third segment of third pair of legs hooked. First pair of abdominal appendages long, deeply bifid; rami slender, straight, parallel, the outer a little longer than the inner, and a little recurved at the tip; in some specimens the anterior border at the base of the rami has a projecting angle or shoulder, but in most specimens this is not evident.

Female. — Fingers straighter. Base of external finger has a dense beard on the inside; in a few of the specimens seen, the fingers are longer, nearly straight, their opposed margins almost meeting throughout their length. Annulus ventralis bilaterally symmetrical, anterior margin bituberculate, posterior margin unituberculate, fossa transverse.

Dimensions of a male, form I. — Length of body, 38 mm. Length of carapace, 19.5 mm. Length of abdomen, 18.5 mm. From tip of rostrum to cervical groove, 14 mm. From cervical groove to posterior border of carapace, 6 mm. Length of rostrum, 5 mm. Length of acumen of rostrum, 2 mm. Width of areola, 1 mm. Length of antenna, 36 mm.

Length of chela, 16 mm. Breadth of chela, 7.5 mm. Length of movable finger, 10.5 mm.

The largest female specimen is 60 millimeters in length.

Locality. — Cypress Creek, Lauderdale Co., Ala.

Nine specimens, four males of the first form and five females, collected by C. L. Herrick for the U. S. National Museum, October, 1882.

This is a small species with large hand, slender fingers widely separated at base and meeting only at the tips. In the female there is a heavy beard at base of external finger on the inner side.

In the summer of 1872, I collected in a brook at Knoxville, Tenn., six specimens, three second-form males and three females, which closely resemble those obtained by Mr. Herrick in Alabama, and belong, I think, to the same species. The external finger of the males is densely bearded within at the base, as in the females from Alabama; the first abdominal appendages reach forward to the base of the second pair of legs, are bifid at the tip, the internal and external parts are thick, blunt at the tip, the outer somewhat longer than the inner, and slightly recurved at the tip.

GROUP V. (Type, C. Montezumæ.)

Third segment of the second and third pairs of legs hooked. First pair of abdominal appendages of the male similar to those of the species included in Group IV.

51. Cambarus Montezumæ.

Plate II. fig. 6, Plate X. figs. 7, 7′, 7 a, 7 a′.

Cambarus Montezumæ, Saussure, Rev. et Mag. de Zool., 2e Sér., IX. 102, 1857. — Mém. Soc. Phys. Hist. Nat. Genève, XIV. 459, Pl. III. fig. 22, 1858.
Cambarus Montezumæ, var. *tridens*, Von Martens, Arch. Naturgesch., XXXVIII. Jahrg., I. 130, 1872.
Cambarus Montezumæ, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 149, 1884.

Cambarus Montezumæ and *C. Shufeldtii* are small species distinguished from all the others of the genus by having hooks on the third joint of the *second and third* pairs of legs of the male. In *C. Montezumæ* the rostrum is plane or lightly concave above, with a slightly raised margin; it varies much in its shape. In the typical form, as described and figured by Saussure, its margins are subparallel from the base to near the extremity, where they con-

verge to form the short acumen, without lateral angle or spine. In other specimens there are lateral spines at the base of the acumen (var. *tridens* of Von Martens), and in an intermediate form the rostrum is simply angulated instead of spinous at the base of the acumen. The sides may be more or less convergent from the base. In specimens from Mazatlan, the rostrum, although destitute of lateral spines, differs from the typical form in being longer and more tapering. The post-orbital ridges are in some specimens unarmed at the anterior end, in others they end in a sharp spine. The fore border of the carapace is angulated under the orbit. No branchiostegian spine. Carapace smooth, punctate on the gastric region and areola. No lateral spine. Areola of moderate width. Abdomen longer than the cephalothorax, broad, especially in the female. Anterior segment of telson armed on each side with one, two, or (seldom) three spines. Antennal scale broad. Chelipeds without spines or tubercles, excepting, in some specimens, one or two spicules at distal end of superior border of the meros; hand of male long, cylindrical, inflated; fingers slender, with cutting edges smooth, meeting throughout their length. In the female the chela is shorter and broader.

In the first form of the male the third segment of the second and third pairs of legs has a sharp hook, the first abdominal appendages are of moderate length, recurved, bifid, the rami divaricate, horny-tipped, the outer one ending in a slender recurved point, and furnished with a single seta on its posterior border, the inner one laterally compressed, spoon-shaped at the end.

The second form of the male has the hooks on the second and third pairs of legs slightly developed, the first pair of abdominal appendages less deeply bifid, the tips of the rami membranous and both blunt.

Annulus ventralis of the female movable, fixed only at the posterior end, between the sterna of the penultimate and the last thoracic somites. The ventral face of the annulus is marked by a longitudinal fossa open at the posterior end.

Saussure's types of *C. Montezumæ* in the Berlin Zoölogical Museum were examined in September, 1870, by Dr. Hagen, who has kindly furnished me with the following information concerning them. The types are in alcohol, male, form I., and female. In the male (young) the rostrum is nearly rounded in front. Another jar contains male, form II., and female, also from Saussure, with tridentate rostrum. The second and third pairs of legs are hooked, as is stated by Saussure.

In Archiv für Naturgeschichte, XXXVIII., 1872, page 130, Von Martens communicates some remarks upon the form with lateral rostral spines, received by the Berlin Museum from Puebla, Mexico, together with the typical *C. Montezumæ* and *C. Azteeus*. This form he calls *Cambarus Montezumæ*, var. *tridens*. The largest part of those which I have myself seen, amounting to about seventy specimens, have the lateral spines on the rostrum, but in some specimens the spines are very small, and in others reduced to a mere angle at the base of the acumen.

Some of the female specimens collected by Prof. A. Dugès, in the collections of the U. S. National Museum, have a short, broad, and hirsute chela.

Five imperfectly preserved dry specimens in the Museum of Comparative Zoölogy come from Mazatlan. These specimens have a rather long, tapering, entire rostrum, but do not differ from *C. Montezumæ* enough to warrant separation. The sexual parts are the same as in the more eastern specimens. It appears from these specimens that the genus Cambarus extends, in Mexico, to the Pacific coast.

There are also in this Museum six specimens, two males, form I., three females, and one young male, collected by Mr. Edward Palmer near Parras, Cohahuila, Mexico, which differ from *C. Montezumæ*, var. *tridens*, in having the section of the carapace posterior to the cervical groove shorter, the areola much broader. This form, which I have named provisionally *C. Montezumæ*, var. *areolata*, may prove to be a good species. But considering the variability of individuals of *C. Montezumæ*, and the small number of Mexican localities from which specimens have been received, I prefer to treat this form as a variety simply, the more because the sexual parts of both male and female are like those of *C. Montezumæ*. In this form, the distance from the cervical groove to the posterior margin of the carapace is half (or even less) the distance from the cervical groove to the lateral rostral spines. The areola is about half as broad as it is long. Length of body, 28 mm.

The largest specimen of *C. Montezumæ* which I have seen measures 38 mm. from tip of rostrum to end of the telson.

Known Localities. — Mexico: marshes of the Valley of Mexico (Saussure); ponds, Chapultepec; Lake Tezcoco,* near city of Mexico; Puebla (Von Martens); Lake San Roque, Trapuato (Coll. U. S. Nat. Mus.); Parras; Mazatlan.

* Lake Tezcoco is said to be salt.

52. Cambarus Shufeldtii.

Plate VII. fig. 1, Plate X. figs. 8, 8′, 8 a, 8 a′.

Cambarus Shufeldtii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 134, 1884.

Male, form I. — Rostrum plane above, margins a little convergent, raised into a slight rim from the base to the lateral spines, which are prominent and acute; acumen of moderate length, acute, pubescent. Post-orbital ridges with anterior spines. Carapace smooth; a sharp spine on the cervical groove on each side; sub-orbital angle prominent, branchiostegian spine present. Areola of moderate breadth. Telson bispinous on each side. Epistoma triangular. Antennal scale broad. Hand smooth, cylindrical, inflated; fingers slender, incurved at the tips. Carpus smooth, armed with a single spine on the antero-inferior border. Meros provided with a single spine near the distal end of the superior margin, and two or three below. Third segment of second and third pairs of legs hooked. First pair of abdominal appendages straight, bifid, inner part ending in a straight, acute tip, outer part split at the tip into two straight acute points.

In the second form of the male the hooks upon the thoracic legs are very slightly developed, and the first abdominal appendages are less deeply cleft, with blunter and less finished tips. The chela is shorter.

In the female the chela is much shorter, broader, and less cylindrical, the abdomen broader. Annulus ventralis a transverse curved ridge, the hind side of the ridge concave.

Length, 19 to 27 mm.

Locality. — Near New Orleans, La.

Found with *C. Clarkii* in the collection made by Dr. R. W. Shufeldt, U. S. A., in 1883, now in the U. S. National Museum.

This is a minute species closely related to *C. Montezumæ* from Mexico. Like that species, it has the *second and third* pairs of legs hooked in the male, a condition which normally obtains in no other species known.* *C. Shufeldtii* is distinguished from *C. Montezumæ* by the presence of a lateral spine on the carapace and by the form of the male appendages. In the latter species the tips of these appendages are recurved, the inner part flattened at the end into a spoon-shaped surface. In *C. Shufeldtii* the tips of these organs are straight, and each of the three points in which they terminate is acute.

* I have seen two or three abnormal specimens of *C. virilis* and *C. propinquus* with a like disposition of hooks on the legs. The same arrangement is found in the three species of Cambaroides from the Amoor River basin and Japan.

ASTACUS.

In the genus Astacus the last thoracic somite bears a gill (pleurobranchia) on each side, the full number of gills being thirty-six (eighteen in each branchial chamber). There are besides two or three rudimentary gills on each side of the body. The hindmost podobranchia is provided with a plaited, bilobed lamina, like those in front. The arrangement of the gills is expressed in the following formula: —

Somite.	Podobranchiæ.	Arthrobranchiæ. Anterior.	Arthrobranchiæ. Posterior.	Pleurobranchiæ.	
VI.	0 (ep.)	0	0	0	= 0 (ep.)
VII.	1	1	0	0	= 2
VIII.	1	1	1	0	= 3
IX.	1	1	1	0	= 3
X.	1	1	1	0 or r	= 3 or $3+r$
XI.	1	1	1	r	= $3+r$
XII.	1	1	1	r	= $3+r$
XIII.	0	0	0	1	= 1
	6 + ep.	+ 6	+ 5	+ 1 + 2 r or 3 r	= 18 + 2 r or 3 r + ep.

The orifice of the green gland is situate on the posterior face of the tubercle. The annulus ventralis is represented by a transverse ridge behind the penultimate thoracic sternum.

The Astaci occupy three widely separated geographical areas: 1. Western North America from the Rocky Mountains to the Pacific Ocean;* 2. The western portion of the Europæo-Asiatic continent, from the Ural Mountains and the basin of the Sea of Aral to the Spanish peninsula and Ireland; 3. Eastern Asia in the Amoor River system (Transbaikaïlia, Territory of Amoor, and Manchooria), and in Japan. No Astaci are known from any part of Siberia between Lake Baikal and the Ural Mountains, or from any of the Siberian rivers that flow into the Arctic Ocean.†

The North American and European Astaci form a natural group (Astacus proper). In these the body is robust and ovate, the first pair of abdominal

* One species, *A. Gambelii*, has invaded the territory of the Cambari, following down the Yellowstone River to its mouth.

† That is, no species known to be indigenous. *A. leptodactylus* has been artificially introduced into the Irtish River basin.

appendages of the male are neither bifid nor toothed at the tip, and there are no hooks near the base of any of the thoracic legs.

The Astaci from Western Asia curiously simulate the Cambari of North America in the general shape of the subcylindrical body and in the form of the chelipeds. The second and third pairs of thoracic legs of the male bear hooks on the third segment similar to those of the male Cambarus, and the first pair of abdominal appendages are terminated with short teeth. The three Asiatic species, *A. Japonicus*, *Dauricus*, and *Schrenckii*, thus form a second natural group, combining some of the characters of Astacus and Cambarus. This group I have called Cambaroides.

Subgenus CAMBAROIDES.

Cephalothorax subcylindrical. Last thoracic segment bearing a pair of pleurobranchiæ. Third segment of second and third pairs of legs of the male hooked. First pair of abdominal appendages of the male terminating in short teeth or tubercles.

The three species *Astacus Japonicus*, *Dauricus*, and *Schrenckii*, from Japan and the basin of the Amoor River, widely separated from the rest of their family in geographical position, form a natural group of subgeneric value, to which I have given the name Cambaroides. In them is found a combination of characters of Astacus and Cambarus. In the general appearance of the body, with its subcylindrical cephalothorax, and in the form of the rostrum and chelipeds, these Asiatic Astacidæ strikingly recall the Cambari of North America, and their affinity is made more evident through the hooked thoracic legs and tooth-tipped sexual appendages of the male. The hooks are situate, in all these species, on the third segment of the second and third pairs of legs, as in *Cambarus Montezumæ* and *Shufeldtii*. The rostrum is devoid of lateral teeth. The carpus is armed with a strong median internal and an anterior inferior spine. The external flagellum of the antennules is serrate below, each segment being produced at its antero-inferior angle, which bears a bundle of eight or ten of Leydig's olfactory organs. These are arranged in a single group on each antennulary segment, instead of being distributed into two bundles, as in Cambarus and Astacus proper.* The front border of the carapace is strongly angulated behind the

* The same arrangement of the olfactory setæ is found in the Parastaciinæ.

eyes. The areola is broad, about one half as broad as long. The telson is notched on each side, and furnished with one or two spines, but it is not divided by a transverse suture. In this respect these species resemble the Parastacinæ of the Southern hemisphere. The transverse suture of the telson is most complete in the genus Cambarus and in the European Astaci. The Astaci of Western North America occupy a middle ground in this regard, the suture being incomplete or absent.

In all the male specimens of Cambaroides that I have seen (one *A. Dauricus*, three *A. Japonicus*), the first abdominal appendages are divided into two sections by a transverse suture. The distal portion of these appendages is so closely rolled and consolidated that a mere groove remains on the inner side. The tip is truncate, and furnished with a few short blunt teeth or tubercles. I suspect the existence of two forms of the male here, as in Cambarus, for in the male specimen of *A. Dauricus* the hooks on the thoracic legs are strongly developed, and some of the teeth at the end of the first abdominal appendages are brown and horny at the tips, whilst in the three male *A. Japonicus* the hooks of the thoracic legs are weak, and the terminal teeth of the first abdominal appendages are smaller and not of a horny texture.

The second pair of abdominal appendages of the male are somewhat different from those in the genera Cambarus and Astacus proper. The terminal part of the endopodite, which retains the membranous character of the exopodite in Cambarus and Astacus proper, is here corneous, very short, and closely applied to the rolled lamella which lies on the inner side of the appendage. The rolled part assumes a somewhat triangular shape, as in Cambarus and the Astaci of Western North America.*

In the female of *A. Schrenckii* there is a transverse tubercle behind the sternum of the penultimate thoracic somite, much as in Astacus proper. In *A. Dauricus* and *A. Japonicus* this transverse tubercle or ridge is hollowed out behind, but still remains closely soldered to the sternum. The first abdominal somite of the female is devoid of appendages, as in the American species of Astacus and in the Parastacinæ.

In the number and arrangement of the gills, Cambaroides agrees with Astacus, and differs from Cambarus.

The post-orbital ridge is slightly developed in all the species. It is least prominent in *A. Japonicus*, in which even the anterior end of the ridge is

* The reader is referred to page 17 of Hagen's Monograph, and to page 146 of Huxley's "Crayfish," for a general description of these appendages in Cambarus and Astacus proper.

barely indicated as a minute tubercle. In *A. Dauricus* the post-orbital spine is more prominent; it lies very close to the margin of the carapace; the ridge continues but a very short distance backward from the spine. In *A. Schrenckii* the spine and ridge are more pronounced, but still small.

The three species may be separated by the following table: —

A. Lateral spine behind the cervical suture. Rostrum convex above . . . . . *A. Schrenckii.*
B. No lateral spine behind the cervical suture. Rostrum concave and lightly carinate above.
a. Rostrum equal in length to peduncle of antennæ. Abdominal pleura narrow, pointed. *A. Dauricus.*
b. Rostrum shorter than peduncle of antennæ. Abdominal pleura broad, rounded. . . *A. Japonicus.*

1. Astacus (Cambaroides) Japonicus.

Plate X. figs. 10, 10′ (first abdominal appendages of male).

Astacus Japonicus, De Haan, Crustacea of Siebold's Fauna Japonica, p. 164, Tab. XXXV. fig. 9, 1842.
Astacus Japonicus, Erichson, Arch. Naturgesch., XII. Jahrg., I. 94, 1846. (After De Haan.)
Astacus Japonicus? Kessler, Bull. Soc. Impér. Nat. Moscou, XLVIII. 364, 1874.
Astacus (*Cambaroides*) *Japonicus*, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 149, 1884.

Habitat. — Japan.

Prof. C. O. Whitman, to whom the Museum of Comparative Zoölogy is indebted for four specimens of this species, informs me, that, during his residence in Japan, he could not learn of its occurrence in Niphon, the main island of the Empire, all the specimens known to him coming from the island of Yesso. Kessler's specimens came from the same locality as Prof. Whitman's, viz. Hakodadi, Yesso.

In the four specimens received from Prof. Whitman, the posterior margin of the telson is rounded, and shows no trace of the deep median notch described and figured by De Haan. In this respect, these examples agree with those described by Kessler. Individuals with similarly notched telson are found in some other species, e. g. *A. Gambelii*, although in these the emargination is less pronounced.

The rostrum terminates in three minute horny points. The branchial formula is the same as in *Astacus fluviatilis*, there being one pleurobranchia (on each side) on the last thoracic somite, and one rudimentary pleurobranchia, in the shape of a simple filament, on each of the three antecedent somites.

The arrangement of the gills is shown in the following table: —

Somite.	Podobranchiæ.	Arthrobranchiæ. Anterior.	Arthrobranchiæ. Posterior.	Pleurobranchiæ.	
VI.	0 (ep.)*	0	0	0	= 0 (ep.)
VII.	1	1	0	0	= 2
VIII.	1	1	1	0	= 3
IX.	1	1	1	0	= 3
X.	1	1	1	r	= $3 + r$
XI.	1	1	1	r	= $3 + r$
XII.	1	1	1	r	= $3 + r$
XIII.	0	0	0	1	= 1
	$6 + \text{ep.}$	$+ 6 +$	$5 +$	$1 + 3r$	$= 18 + 3r + \text{ep.}$

The structure of the gills and coxopoditic setæ is the same as in the Astaci proper.

2. Astacus (Cambaroides) Dauricus.

Plate X. figs. 9, 9′ (first abdominal appendages of male).

Astacus Dauuricus, Pallas, Spicilegia Zoologica, Fasc. IX. p. 81, 1772.
Cancer Dauuricus, Pallas, l. c.
Dauurische Krebs, Herbst, Versuch Naturgesch. Krabben u. Krebse, II. 42, 1796. (After Pallas.)
Astacus leptorrhinus, Fischer, Bull. Soc. Impér. Nat. Moscou, IX. 467, Tab. V. fig. 1, 1836.
Astacus Dauricus, Erichson, Arch. Naturgesch., XII. Jahrg., I. 94, 1846.
Astacus Dauuricus, Gerstfeldt, Mém. Acad. Impér. Sci. St. Pétersbourg, VIII. 292, 1859.
Astacus Dauricus, Kessler, Bull. Soc. Impér. Nat. Moscou, XLVIII. 361, 1874.
Astacus (*Cambaroides*) *Dauricus*, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 151, 1884.

Habitat. — Upper portion of the Amoor River basin as far down as Albasin, including the rivers Ingoda, Argoon, Onon, Shilka, and Nercha. It is not found in the Gasimoor, a tributary of the Argoon (Gerstfeldt, Kessler).

3. Astacus (Cambaroides) Schrenckii.

Plate VI. fig. 3.

Astacus Schrenckii, Kessler, Bull. Soc. Impér. Nat. Moscou, XLVIII. 363, 1874.
Astacus (*Cambaroides*) *Schrenckii*, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 151, 1884.

Habitat. — Lower part of the basin of the Amoor River (Kessler).

In the form of the rostrum and in the possession of a lateral thoracic spine, *A. Schrenckii* bears less resemblance to *A. Dauricus*, from the upper part of the same river basin, than *A. Japonicus* does. On the other hand, the chelæ and abdominal pleura of *A. Schrenckii* are very much like those of *A. Dauricus*, while in *A. Japonicus* the chelæ are much shorter and broader, the abdominal pleura broader and more rounded, than in the Amoorland species.

* The epipodite of the first maxilliped bears no branchial filaments.

In the remaining species of Astacus the first abdominal appendages are simply rolled, never bifid nor toothed at the end, neither are there hooks on any of the thoracic legs in the male.

THE NORTH AMERICAN ASTACI.

Six species of Astacus have been described from Western North America, viz.: — *A. Oregonus* Randall, 1839; the type of this species was lost, and the figure and description are insufficient for its determination; it is perhaps the same as *A. leniusculus* Dana. *A. Gambelii* Agassiz, first described as a Cambarus in 1852 by Girard; the types of Girard are in the Philadelphia Academy. *A. leniusculus* Dana, 1852; type in the collection of the Smithsonian Institution, Washington, D. C. *A. nigrescens*, *A. Trowbridgii*, and *A. Klamathensis*, described by Stimpson in 1857; there are types of *A. Trowbridgii* in the Smithsonian Institution, the Museum of Comparative Zoölogy, and the Peabody Museum of Yale College; Dr. Hagen examined types of *A. nigrescens* and *A. Klamathensis* communicated by Stimpson.

Distribution. — The nearly related species *A. leniusculus* and *A. Trowbridgii* are found in the lower part of the Columbia River, Puget Sound, and adjacent regions. To the southward near the coast, in the neighborhood of San Francisco, *A. nigrescens* appears to be the dominant species. It perhaps extends northward near the coast as far as Alaska. In the more elevated regions of the Northwest, in Oregon, Washington Territory, and British Columbia, *A. Klamathensis* is found. The most eastern of the American Astaci is *A. Gambelii*, which is found in the Great Salt Lake Valley and in the upper waters of the Snake River, Idaho. From this region it has passed over the divide into the Yellowstone Valley, and invaded the domain of the Cambari as far as the confluence of the Yellowstone and Missouri Rivers. An examination of the physical geography of this region shows that the migration of a Western species into the Mississippi basin at this point is no difficult matter, the divide separating the waters of the Yellowstone from those of the Snake River being very low, hardly above the level of the ancient Yellowstone Lake.*

Compared with the European species, the American Astaci have the

* See W. H. Holmes's Report on the Geology of the Yellowstone National Park, in Twelfth Ann. Rep. U. S. Geolog. and Geograph. Survey of the Territories for 1878, Part II. p. 56, 1883.

telson less clearly divided by a transverse suture, and the first pair of male appendages are more closely rolled, with a more pointed and membranaceous tip.

I have examined the branchiæ of *A. Klamathensis*, *A. nigrescens*, and *A. Gambelii*. In all of them the formula is the same as for *A. fluviatilis*, there being three rudimentary gills on each side of the thorax. In *A. nigrescens* the two anterior ones are short, but thick. They are more highly developed in *A. Gambelii* than in any other species of Astacus examined, presenting an interesting approach in structure to the perfectly developed gill. Each of the rudimentary gills is much larger than in any other species, and is jointed at a short distance from the base. At the joint there are, in the intermediate pair, two short lateral branches, one on each side; in the anterior and posterior pairs the main stem bears one lateral filament.

I find no trace of appendages on the first abdominal somite of the female in any of the American species of Astacus.

The five American species of Astacus may be distinguished as follows: —

A. Margins of the rostrum not denticulated.
  a. Rostrum short, with short acumen. Post-orbital ridge without posterior spine. *A. Klamathensis.*
  b. Rostrum long, with long acumen. Post-orbital ridge with a posterior spine or tubercle.
    α. Posterior spine of post-orbital ridge long and acute. Areola one half as broad as long . . . . . *A. leniusculus.*
    β. Posterior spine of post-orbital ridge small, sometimes reduced to a tubercle. Areola one third as broad as long . . . . . *A. Trowbridgii.*
B. Margins of the rostrum denticulated.
  a. Rostral acumen long. Posterior spine of post-orbital ridge prominent. Chela not barbated . . . . . *A. nigrescens.*
  b. Rostral acumen short. No posterior spine on post-orbital ridge. Chela barbated . *A. Gambelii.*

1. Astacus Klamathensis.

Plate VI. figs. 1, 2.

Astacus Klamathensis, Stimpson, Proc. Bost. Soc. Nat. Hist., VI. 87, February, 1857. — Journ. Bost. Soc. Nat. Hist., VI. 494, April, 1857.

Astacus Klamathensis, Spence Bate, in Lord's "Naturalist in Vancouver Island and British Columbia," II. 278, 1866. (No description.)

Astacus Klamathensis, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 93, Pl. III. fig. 169, 1870.

Astacus Klamathensis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 151, 1884.

Known Localities. — Oregon: Klamath Lake (Stimpson); Sikan Creek; Des Chutes River. Washington Terr.: Fort Walla Walla; Wenas Valley; Spokane Falls. British Columbia: streams east of the Cascades (Bate).

Stimpson's types were found in Klamath Lake by Dr. Newberry. One of these, a female, was described by Hagen. It is common at Fort Walla

Walla, judging from the number collected at that place by Captain Charles Bendire, U. S. A. These specimens are in the U. S. National Museum.

Specimens from Sikan Creek, Oregon, differ in some respects from those received from Washington Territory, the sides of the rostrum converging more (as described by Stimpson and Hagen in the Klamath Lake specimens) and ending in a longer acumen. In the specimens from Fort Walla Walla the rostrum is quadrangular, with shorter acumen. In the Oregon specimens the cervical groove is more broadly sulcate, the posterior portion of the cephalothorax broader, the carapace impressed on each side of the median line of the cardiac region and less densely punctate; the abdomen of the female is more expanded anteriorly, the internal margin of the antennal scale tapers off more gradually from the middle to the tip, and the hand is longer.

In small specimens of *A. Klamathensis* there is a sharp spine at the antero-interior angle of the carpus; the rostral acumen is longer, and the post-orbital spines longer and sharper than in the adult.

In some adult specimens a faint trace of a posterior post orbital spine is to be seen on close examination as a minute brown-horny granule, similar in appearance to the tip of the front end of the post-orbital ridge. This granule occupies exactly the place of the hinder post-orbital spine of *A. Trowbridgii*, etc.

Length, 95 mm.

2. Astacus leniusculus.

Plate VI. fig. 4.

Astacus leniusculus, Dana, Crustacea U. S. Explor. Exped., Pt. I. p. 524, Pl. XXXIII. fig. 1, 1852.
Astacus leniusculus, Stimpson, Journ. Bost. Soc. Nat. Hist., VI. 493, 1857.
Astacus leniusculus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 94. (After Dana and Stimpson.)
Astacus leniusculus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 151, 1884.

Known Localities. — Washington Territory: Columbia River; Puget Sound (Dana, Stimpson).

One of Dana's types is in the collection of the Smithsonian Institution (U. S. Explor. Exped., No. 375, Smithson. Inst., No. 2019). The rostrum of this specimen, a male, is mutilated and deformed. Two more male specimens are in the same Museum (Cat. No. 2161) without any label indicating their origin.*

The hands are of unequal size, the left being the larger. Dana says that

* One of these is now in the Museum of Comparative Zoölogy (Cat. No. 3655). This is the one figured on Plate VI. of this work.

in young specimens the posterior spines of the carapace are obsolescent and the hands of nearly equal size. Judging from his figure, 1 *b*, the postcarapace is also longer. Perhaps these young specimens were *A. Trowbridgii* Stimpson.

A. leniusculus is closely related to *A. Trowbridgii*. For the distinctions, see under the latter species.

The posterior margin of the anterior segment of the telson is bi- or trispinous on each side. The cone at the orifice of the green gland ("auditory tubercle") terminates in a sharp spinule; in *A. Trowbridgii* it is blunt. The spines on the second and third segments of the antennæ are prominently developed and acute. The anterior process of the epistoma is triangular, similar in form to that of *A. Trowbridgii*. The fingers are spinulose at the distal ends, as in *A. Trowbridgii*.

Astacus Oreganus.

Astacus Oreganus, Randall, Journ. Acad. Nat. Sci. Phila., VIII. 138, Pl. VII., 1839.
Astacus Oreganus, De Kay, Zoölogy of New York, Pt. VI., Crustacea, p. 23, 1844. (After Randall.)
Astacus Oreganus, Ericuson, Arch. Naturgesch., XII. Jahrg., I. 375, 1846. (After Randall.)
Cambarus Oreganus, Girard, Proc. Acad. Nat. Sci. Phila., VI. 87, 1852. (After Randall. No description.)
Astacus Oreganus, Stimpson, Journ. Bost. Soc. Nat. Hist., VI. 495, 1857. (After Randall.)
Astacus Oreganus, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 95, 1870. (After Randall.)

"Testa granulata, bimaculata, fronte valde producta.

"Body fuscous, granulated, carpus with a sharp spine at the inner angle; arm produced into a spine on each side anteriorly; thorax behind the front with five spines, placed three before and one on each side behind the lateral ones; a large reddish spot on each side posteriorly; front little reflexed on the sides, terminating in a very long slender spine, and having a short marginal spine on each side.

"Length about four inches.

"Taken by Mr. Nuttall in the Columbia River, west coast of North America."—Randall.

The type of *A. Oreganus* was lost or destroyed while in the hands of the artist by whom the drawing was made,* and no specimen answering to the description and figure has since been found. The figure given by Randall is very faulty, as has been pointed out by Hagen. The tri-articulate structures interpreted by Hagen as badly drawn antennal scales are, I think, the three distal segments of the third maxillipeds, the antennal scale not being represented at all. Dr. Hagen thinks that the median spine at the base of the rostrum may be a carinated elevation simply, such as is seen in *A. nigrescens* (he might have added also *A. Trowbridgii* and *A. leniusculus*). The drawing might well be thus explained, but it is hard to make Randall's explicit mention of *five* spines accord with such an interpretation. I incline, nevertheless, to Dr. Hagen's opinion, that this specimen was no other than *A. leniusculus* Dana. The short post-carapace and long rostral acumen agree better with that species than with *A. Trowbridgii*.

* See Proc. Acad. Nat. Sci. Phila., V. 30.

3. Astacus Trowbridgii.

Astacus Trowbridgii, Stimpson, Proc. Bost. Soc. Nat. Hist., VI. 87, February, 1857. — Journ. Bost. Soc. Nat. Hist., VI. 493, April, 1857.
Astacus Trowbridgii, J. G. Cooper, Rep. U. S. Pacific R. R. Expl., XII. Pt. II. 388, 1860.
Astacus Trowbridgii, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 93, Pl. III. fig. 171, Pl. X., 1870.
Astacus Trowbridgii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 152, 1884.

Known Localities. — Oregon: Columbia River, near Astoria. Washington Territory: streams running into Shoalwater Bay (J. G. Cooper).

There are types of *A. Trowbridgii* in the collections of the U. S. National Museum, the Peabody Museum of Yale College, the Boston Society of Natural History, and the Museum of Comparative Zoölogy. There are also two specimens in the Academy of Natural Sciences of Philadelphia. One of the two female types in the collection of the Boston Society of Natural History is figured by Hagen. The spine on the third segment of the antenna is commonly longer than represented by Hagen.

In the larger specimens the posterior pair of spines on the carapace may be obsolete, while in other specimens these spines, although smaller than the anterior pair, are well developed, with acute, brown, horny tips.

The dimensions of a large specimen as given by Stimpson are as follows: — Length of body, 4.80 in.; breadth, 1.30 in. Length of rostrum, 0.50 in.; acumen of rostrum, 0.18 in.; hand, 2.60 in.; breadth of hand, 1.15 in.

The areola is two and one half times as long as it is broad. The distance from the tip of the rostrum to the cervical groove is but a trifle more than twice the distance from the cervical groove to the posterior margin of the carapace. The length of the acumen of the rostrum is equal to the distance between the lateral spines of the rostrum. The tips of the first pair of abdominal appendages of the male are delicately membranous.

Of the eleven specimens (six males, five females) which I have seen, nine are types collected by Lieut. Trowbridge in the Columbia River above Astoria, Oregon. Of the other two, in the Philadelphia Academy, one is labelled Columbia River, the other is without locality. According to Cooper, it is also found in the streams running into Shoalwater Bay, Washington Territory, to the north of Columbia River, and even in the brackish water of the bay. According to the same authority, its color, when fresh, is olive above; pale, tinted with red, below.

A. Trowbridgii is closely related to *A. leniusculus*. It differs from it in the following particulars: the body is more obese; the cephalothorax is broader

posteriorly, in *A. leniusculus* more cylindrical; the carapace is less punctate and less ciliate; the rostrum is shorter and broader, with shorter acumen, the distance between the lateral spines of the rostrum being equal to the length of the acumen, whereas in *A. leniusculus* the length of the acumen much exceeds the distance between the lateral spines; the length of the part of the carapace posterior to the cervical suture is greater, being very nearly equal to half the distance from the cervical groove to the tip of the rostrum, while in *A. leniusculus* the latter distance is twice and one half the distance from the cervical groove to the posterior margin of the carapace; the areola is longer and narrower, considerably more than twice as long as broad, while in *A. leniusculus* it is much less than twice as long as broad; the spines on the carapace behind the eyes are less developed, especially the posterior ones, and the chela is broader.

4. Astacus nigrescens.

Astacus nigrescens, Stimpson, Proc. Bost. Soc. Nat. Hist., VI. 87, February, 1857. — Journ. Bost. Soc. Nat. Hist., VI. 492, April, 1857.
Astacus nigrescens, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 92, Pl. III. fig. 168, 1870.
Astacus nigrescens, Huxley, The Crayfish, p. 244, fig. 61, C, F, I, fig. 62, C, F, 1880.
Astacus nigrescens, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 152, 1884.

Known Localities. — California: San Francisco. Washington Territory: Fort Steilacoom (Coll. U. S. Nat. Mus.). Alaska Territory: Oonalaska (Coll. U. S. Nat. Mus.).

In most specimens the post-orbital ridges are reduced to an anterior and posterior spine, but in some there is a third spine between these two. The ridge that represents the annulus ventralis of the female Cambarus is broadly notched in the middle.

A female specimen in the U. S. National Museum, from Fort Steilacoom, Washington Territory (No. 2526), differs as follows from the typical form: the sides of the rostrum are less inflated and more convergent, the acumen shorter; the margin of the telson has only one spine on each side; the hand is shorter, smoother, more coarsely punctate, the spines of the meros less developed; the branchial regions of the carapace and the abdominal pleura are more coarsely punctate.

A male specimen in the same Museum is labelled "Oonalaska, W. H. Dall." The rostrum of this specimen (No. 8954) is aborted and deformed, the chela longer than usual. The locality, if correct, is an interesting one.

Another large male specimen, five inches long, in the U. S. National Museum, from T. G. Scupham, California (No. 2267), is labelled "*Astacus Oregonensis* Nutt.," and by this name it is recorded by W. H. Dall in his "Catalogue of Illustrations of the Economical Invertebrates of the American Coasts," Bull. U. S. Nat. Mus, No. 14, p. 260, 1879. Randall's *A. Oreganus* was collected by Nuttall in the Columbia, but was certainly not *A. nigrescens*. (See p. 133.)

Types of *A. nigrescens* were sent to Dr. Hagen by Stimpson. These were probably afterwards destroyed in the great fire at Chicago.

It is said by Stimpson to be common in the vicinity of San Francisco, and to be sold in the market of that city.

"Color, blackish." Stimpson.

The first abdominal appendages of the male *A. nigrescens* are incorrectly figured by Huxley in "The Crayfish," p. 245, fig. 62, C, and by Brocchi in Ann. Sci. Nat., 6e Sér., Zool. et Paléont., Tom. II., Pl. XIII. figs. 10, 11.

5. Astacus Gambelii.

Cambarus Gambelii, Girard, Proc. Acad. Nat. Sci. Phila., VI. 90, 1852, 380, 1853.
Astacus Gambelii, Agassiz, Proc. Acad. Nat. Sci. Phila., VI. 375, 1853.
Astacus Gambelii, Stimpson, Journ. Bost. Soc. Nat. Hist., VI. 492, 1857.
Astacus Gambelii, Hagen, Ill. Cat. Mus. Comp. Zoöl., No. III. p. 90, Pl. I. figs. 97, 98, Pl. III. fig. 170, Pl. XI. 1870.
Astacus Gambelii, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 152, 1884.

Known Localities. — Utah: Ogden River, Ogden. Idaho: Fort Hall (Coll. U. S. Nat. Mus.); west side of Teton Basin (Coll. U. S. Nat. Mus.). Montana: mouth of Yellowstone River. Wyoming: Willow Creek (?). California: Santa Barbara (?).

Girard's types are in the Museum of the Academy of Natural Sciences of Philadelphia. One of them has been figured by Hagen.

The female, as well as the male, has the peculiar beard on the chela. The lower side of the peduncles of the antennæ is also barbate in both sexes. In some specimens the telson is notched in the middle of the hind border, in other specimens it is entire.

Two dozen fine specimens of this species were collected by Mr. J. A. Allen at Ogden, Utah, in September, 1871. The largest of these measure 95 mm. in length. Ogden City is on Ogden River, which flows into Great Salt Lake. In the U. S. National Museum are specimens from a warm spring at Fort Hall, and from the west side of Teton Basin. Both of these locali-

ties are in Idaho, in the upper part of the area drained by the Lewis Fork of the Columbia River. There are also four small specimens collected by the Hayden Survey at the mouth of the Yellowstone River, which joins the Missouri River at the western boundary of Dakota. Besides these there are two young specimens in the same collection, labelled "Willow Creek, Oct. 9, 1872, Dr. Curtis." An added ticket reads "Wyoming Terr.?" Willow Creek in Wyoming Territory flows into the South Fork of the Platte River, another affluent of the Missouri. The correctness of the tickets accompanying the Yellowstone River specimens is at any rate unquestioned, and it thus appears that this species has encroached upon the territory of Cambarus in the area drained by tributaries of the Missouri River. The Teton Basin specimens, it will be observed, come from a locality not far from the water-shed dividing the waters which flow into the Pacific Ocean from those which find their outlet in the Gulf of Mexico.*

Girard's types, collected by Dr. Gambel, are said to have come from California; but whether they were taken within the present limits of that State I do not know. The only other specimens of *A. Gambelii* seen by me which could possibly have come from California are a few in the U. S. National Museum (No. 4855), labelled, "Found in bottle containing specimens from Santa Barbara, Dr. Webb." I doubt whether these were collected at Santa Barbara. I have seen no authentic specimens from California.

THE EUROPEAN ASTACI.

In addition to the long and well known *Astacus fluviatilis* Auct., several European forms have been described and named as distinct species from time to time, so that there now stand on record eleven nominal species from within the limits of Europe, viz.: *Astacus fluviatilis* Rondelet (1555), *Cancer torrentium* Schrank (1803), *A. leptodactylus* Eschscholtz (1823), *A. saxatilis* Koch (1835?), *A. tristis* Koch (1835), *A. angulosus* Rathke (1836), *A. pachypus* Rathke (1836), *A. Caspius* Eichwald (1838), *A. longicornis* Lereboullet (1858), *A. pallipes* Lereboullet (1858), and *A. fontinalis* Carbonnier (1869). To these was added a twelfth closely allied species, *A. Colchicus* Kessler (1876), from the Rion River, south of Mount Caucasus.

In 1846 all the Astacidæ described down to that date underwent a re-

* See page 130.

vision by Erichson.* Of the described European species, *A. angulosus* Rathke, *A. pachypus* Rathke, and *A. Caspius* Eichwald, were known to Erichson only through the previous descriptions. He suggests that *A. Caspius* may prove to be the same as *A. pachypus*, a surmise that was afterwards shown by Gerstfeldt to be just. Erichson had the opportunity to examine Koch's types of *A. torrentium*, *saxatilis*, and *tristis*, and notes their clear specific separation from *A. fluviatilis*, and their close affinity with each other. He shows that the dark color of *A. tristis* is due to a coating of adhesive mould, and dismisses the question of the specific value of the differences with the remark that the distinctions may have been more evident in living specimens.

In 1859 the European Astaci were subjected to a second revision at the hands of Gerstfeldt.† The material at Gerstfeldt's command was rich in specimens from Russia, but poor in examples from Central and Western Europe. Gerstfeldt reaches the conclusion, that all the described European species of Astacus may be reduced to two valid species, *A. fluviatilis* and *A. torrentium* (Steinkrebs). He justly points out the identity of *A. pachypus* Rathke and *A. Caspius* Eichwald, and further claims that *A. leptodactylus* Eschscholtz, *A. angulosus* Rathke, and *A. pachypus* Rathke, are but varieties of *A. fluviatilis*, resulting from conditions of climate and of the water inhabited by the several forms. Of the so-called Steinkrebse of the central and western parts of Europe, Gerstfeldt appears to have had but five specimens, all from the Rhone. These he regards the same with *Cancer torrentium* Schrank, *A. saxatilis* Koch, *A. tristis* Koch, and *A. longicornis* Lereboullet. In reality Gerstfeldt's Steinkrebse belonged to the species described and figured the previous year (in a memoir unknown to Gerstfeldt) by Lereboullet,‡ under the name *A. pallipes* (Dohlenkrebs), a distinct form from *Cancer torrentium* Schrank (= *A. saxatilis*, *tristis*, and *torrentium* of Koch, *A. longicornis* of Lereboullet).

In 1869 Heller § described five species from Southern Europe; viz. *A. fluviatilis* Rondelet, *A. leptodactylus* Eschscholtz, *A. angulosus* Rathke, *A. pachypus* Rathke, and "*A. saxatilis* Koch." As synonymes of *A. saxatilis*, Heller includes *A. saxatilis* Koch, *A. tristis* Koch, *A. torrentium* Schrank et Koch, and *A. fluviatilis* Bell. Heller's *A. saxatilis* is the species described by Lereboullet

* Uebersicht der Arten der Gattung Astacus. Arch. Naturgesch., XII. Jahrg., pp. 86–103, 1846.

† Ueber die Flusskrebse Europa's. Mém. Acad. Impér. Sci. St. Pétersbourg, IX. 549–589, 1859.

‡ Description de deux nouvelles Espèces d'Écrevisses de nos Rivières. Mém. Soc. Sci. Nat. Strasbourg, Tom. V., 1858, 11 pp. 3 pl.

§ Die Crustaceen des südlichen Europa. Crustacea Podophthalmia, pp. 212–218, Taf. VII. figs. 3–6, 1863.

as *A. pallipes* (= *A. fluviatilis* Bell), and not *A. saxatilis* Koch (= *A. torrentium* Schrank).

A careful treatise by Kessler* on the Astaci found within the territory of the Russian Empire appeared in 1874. With regard to the European forms, Kessler, in opposition to Gerstfeldt, decides that *A. fluviatilis* Auct., *A. pachypus* Rathke (= *A. Caspius* Eichwald), and *A. leptodactylus* Eschscholtz, are good species, while he considers *A. angulosus* to be a local variety of *A. leptodactylus* which has arisen in the stony mountain streams of the Crimea and Caucasus. Kessler has had unrivalled facilities for forming a correct judgment concerning the specific value of the different forms of Russian crayfishes, hundreds of specimens of both sexes and of different stages of development having passed through his hands. His direct testimony as to the absence of intermediate forms between the three species indicated above appears to me conclusive, and a careful study of all the material accessible leads me to coincide entirely with his views.

The Astaci of Middle and Southern Europe were revised in 1882 by Klunzinger,† who confirms Lereboullet in his conclusion that there are two species besides *A. fluviatilis* in that part of Europe which lies to the west of Russia. To Lereboullet's *A. longicornis* he restores the older name of Schrank, *A. torrentium* (= *A. saxatilis*, *tristis*, and *torrentium* of Koch). The distinctions between this species and *A. pallipes*, or the Dohlenkrebs of Lereboullet, are given in detail, and the identity of the latter with *A. saxatilis* of Heller, the Steinkrebs from the Rhone of Gerstfeldt, and probably with *A. fontinalis* of Carbonnier, is pointed out.

The twelve nominal species enumerated above are thus reduced to six: *A. fluviatilis* Rond., *A. torrentium* (Schrank), *A. leptodactylus* Eschsch. (with var. *angulosus*), *A. pachypus* Rathke, *A. pallipes* Lereb., and *A. Colchicus* Kessl.

In *Astacus fluviatilis* there are three rudimentary pleurobranchiæ on each side of the body, upon the tenth, eleventh, and twelfth body-segments,‡ while in *A. pallipes* there are but two, the anterior one being aborted.§ In the place of the anterior one a small papilla can be discerned, evidently the last vestige of the lost branchia. I have further examined the branchiæ of

* Die Russischen Flusskrebse. Vorläufige Mittheilung. Bull. Soc. Impér. Nat. Moscou, XLVIII. 343–372, 1874.

† Ueber die Astacus-Arten in Mittel- und Südeuropa und den Lereboullet'schen Dohlenkrebs insbesondere. Jahreshefte d. Vereins f. vaterländische Naturkunde in Württemberg, XXXVIII. Jahrg., pp. 326–342, 1882.

‡ Counting the antennulary somite as the first.

§ The difference in the number of rudimentary pleurobranchiæ in *A. fluviatilis* and *A. pallipes* was first noticed by Huxley, The Crayfish, p. 295, 1880.

A. torrentium, *A. leptodactylus*, and *A. Colchicus*. The first of these possesses two rudimentary pleurobranchiæ on each side of the body, like *A. pallipes;* of the anterior pleurobranchia I find not the slightest trace. In *A. leptodactylus* and *A. Colchicus* three are present, although in the former the second and third are very short.

In so far as the reduction of the branchiæ can be taken as a clew to the affinities of the various species of European Astaci, *A. pallipes* and *A. torrentium* are the furthest removed from the primitive form. This accords with Huxley's suggestion, that the Ponto-Caspian species are the modern representatives of the original Eastern stock, while the "Stone Crayfishes"* represent an ancient offshoot, or western wave of migration, which was followed by an invasion of *A. fluviatilis*, just as at the present day, according to Kessler, the latter species is in its turn succumbing to *A. leptodactylus* in the Baltic area.† Following up this line of thought, we must conclude that, of the two species *A. torrentium* and *A. pallipes*, the former represents the older offshoot from the original stock, an offshoot which has retreated before the invading *A. pallipes* to the mountain regions of Central Europe. For not only in the condition of its branchiæ, but also in its general form, *A. pallipes* stands between *A. torrentium* and *A. fluviatilis*.‡

In the European Astaci the first abdominal segment of the female carries a pair of small, simple appendages. They are smaller than in the genus Cambarus, but not aborted,§ as in the American Astaci, in Cambaroides, and in the Parastacinæ of the Southern hemisphere.

In *A. torrentium* and *A. pallipes* the first abdominal appendages of the male are divided into two lobes at the tip by a shallow cleft, the inner and the outer parts being of about equal length. In the other species the outer part is truncate, while the inner part projects beyond it. In *A. pachypus* and *A. Colchicus* the projecting tip of the inner part is longer than in *A. fluviatilis* and *A. leptodactylus*.

The European Astaci, including *A. Colchicus* from the Rion River, Transcaucasia, may be distinguished by the following table: —

* I. e. *A. pallipes* and *A. torrentium*, which Huxley confounds together as one species.

† Vide Huxley, *op. cit.*, p. 321.

‡ Klunzinger (*op. cit.*, p. 331) goes so far as to assert that *A. pallipes* is more closely related to *A. fluviatilis* than to *A. torrentium*, but it does not seem so to me. *A. fluviatilis*, *A. leptodactylus* (including the form *A. angulosus*), *A. pachypus*, and *A. Colchicus* form a natural group of closely related species opposed to the group containing the two Western species, *A. pallipes* and *A. torrentium*.

§ Huxley affirms, however, that these appendages are sometimes wanting in English crayfishes (*A. pallipes*). The Crayfish, p. 116.

A. One tubercle on each side of the base of rostrum.
  a. Tip of rostrum not exceeding the distal end of the penultimate segment of antennule. Rostrum not carinate at the tip. No spines on the sides of the carapace behind the cervical groove . . . . . *A. torrentium.*
  b. Tip of rostrum almost attaining the distal end of the terminal segment of the antennule. A keel or median crest near the tip of the rostrum. One or more spines on the sides of the carapace behind the cervical groove . . . . . *A. pallipes.*

B. Two tubercles, one behind the other, on each side of the base of the rostrum.
  a. Margin of rostrum not denticulate.
    α. Margin of rostrum granulated, not continued back of the anterior post-orbital tubercle. Posterior post-orbital tubercle slightly developed . . . . . *A. fluviatilis.*
    β. Margin of rostrum smooth, continued back on the carapace as a distinct ridge as far as the posterior post-orbital tubercle. Posterior post-orbital tubercle well developed, provided with a spine . . . . . *A. Colchicus.*
  b. Margin of rostrum denticulate.
    α. Chela flat. Rostrum longer than peduncle of antennule. Basal angle of external border of antennal scale spinous . . . . . *A. leptodactylus.*
    β. Chela thick. Rostrum equal in length to peduncle of antennule. Basal angle of external border of antennal scale not spinous . . . . . *A. pachypus.*

6. Astacus torrentium.

Cancer torrentium (Steinkrebs), Schrank, Fauna Boica, III. 247, 1803.
Astacus torrentium (Steinkrebs), Wolf, Mag. neuesten Zustand Naturkunde, herausgegeb. v. Johann Heinrich Voigt, XI. 42–45, Taf. I. figs. 1, 2, 1806.
Astacus saxatilis, Koch, Deutschlands Crustaceen, Myriapoden und Arachniden, Heft 7, No. 1, with fig. (Panzer and Herrich-Schäffer's Deutschlands Insecten, Heft 140, No. 1), 1835?
Astacus tristis, Koch, *op. cit.*, Heft 7 (140), No. 2, with fig., 1835?
Astacus torrentium, Koch, *op. cit.*, Heft 36 (186), No. 24, with fig., 1841.
Astacus torrentium, Erichson, Arch. Naturgesch., XII. Jahrg., I. 92, 1846.
Astacus saxatilis, Erichson, *op. cit.*, p. 92, 1846.
Astacus tristis, Erichson, *op. cit.*, p. 93, 1846.
Steinkrebs, Lereboullet, Comptes Rendus Acad. Sci. Paris, XXXIII. 379, 1851.
Astacus longicornis, Lereboullet, Mém. Soc. Sci. Nat. Strasbourg, V. 2 (separate pagination), Pl. I. figs. 2–2d, 1858.
Astacus torrentium (Steinkrebs) (in part), Gerstfeldt, Mém. Acad. Impér. Sci. St. Pétersbourg, IX. 574, 579, 581, 584, 1859. (After Koch, Erichson, and Lereboullet.)
Astacus torrentium (Steinkrebs), Klunzinger, Jahresh. Vereins vaterländl. Naturkunde Württemberg, XXXVIII. Jahrg., p. 340, 1882.
Astacus torrentium, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 153, 1884.

Koch's *A. saxatilis*, *A. tristis*, and *A. torrentium* are without doubt one and the same species, equivalent to *A. torrentium* (Schrank) Wolf. According to Koch, *A. saxatilis* is distinguished by a slightly carinated rostrum, whereas in *A. tristis* and *A. torrentium* the rostrum is not carinated; but Erichson, who examined Koch's types, tells us that there is an indication of a median rostral carina in *A. tristis* and *A. torrentium* also. The carina is certainly shown in an exaggerated form in all of Koch's figures. The dark color of *A. tristis* came from a coating of mould, according to Erichson, and the broad abdomen is simply a sexual character.

The best illustrations of this species are Lereboullet's (under the name *Astacus longicornis*).

Klunzinger's memoir clearly brings out the specific characters of this species and *A. pallipes*.

Although a faint median rostral carina may exist in *A. torrentium*, it never rises into a prominent sharp crest near the tip, as in *A. pallipes*. Commonly there is no spine on the lower side of the first antennulary segment, but in a specimen in the Museum of Comparative Zoölogy, without locality, I find it quite well developed, as it always is in *A. pallipes*.

I have examined the gills of this species in a specimen from Bohemia in the U. S. National Museum, and find them to agree in number and disposition with those of *A. pallipes*. See page 140.

Distribution. — *Astacus torrentium* is found in the central part of Europe, especially in Germany; but as it has been confounded generally by authors with *A. pallipes* and *A. fluviatilis*, the data are insufficient to determine the limits of its distribution. It is not found to the eastward within the territory of Russia (Kessler). I have seen a specimen (in U. S. National Museum) from Bohemia. It is widely spread through Bavaria and Würtemberg in the mountain lakes, and in the brooks and rivers of the Danube and Neckar river systems. Particular localities recorded in Bavaria are Würm-See (Schrank, *op. cit.*, p. 247; Wolf, *op. cit.*, p. 42; *A. fluviatilis* also inhabits the same lake); mountainous parts of Oberpfalz; near Bodenstein; also in the Danube (Koch) and Kochel-See (Klunzinger). In Würtemberg it has been found in the Neckar, the Nagold, and various small streams of the Neckar and Danube basins (Klunzinger). It is also found in Alsace in the rivers Ill and Bruche, near Strasburg (Lereboullet). How far to the northward it extends in Germany, and whether it passes to the west into France, I cannot determine. All the French specimens which I have seen are *A. pallipes* and *A. fluviatilis*. On the whole, it would seem that *A. torrentium* is a form chiefly found in the mountainous and upland regions of Central Europe.

7. Astacus pallipes.

? *Astacus astacus*, Pennant, British Zoölogy, IV. 18, Pl. XV. fig. 27, 1777.

† *Astacus fluviatilis*, Leach, Trans. Linn. Soc. London, Vol. XI. Pt. II. p. 344, 1815. (No description.)

Astacus fluviatilis (in part), Milne Edwards, Hist. Nat. Crust., II. 330, 1837. (First "variety" noted on p. 331.) — Cuvier's Règne Animal, Disciples' ed., Crustacés, Pl. XLIX. fig. 2.

Dahlenkrebs, Lereboullet, Comptes Rendus Acad. Sci. Paris, XXXIII. 376, 1851. (Treated as a variety of *A. fluviatilis*.)

Astacus fluviatilis, Bell, Hist. British Stalk-eyed Crustacea, p. 237, with cut, 1853.

Astacus pallipes, Lereboullet, Mém. Soc. Sci. Nat. Strasbourg, V. 7 (separate pagination), Pl. II., III. figs. 3–3d, 1858.

Astacus pallipes, var. *flavus*, Lereboullet, Mém. Soc. Sci. Nat. Strasbourg, V. 9, 1858.

Astacus torrentium (Steinkrebs) (in part), Gerstfeldt, Mém. Acad. Impér. Sci. St. Pétersbourg, IX. 577, 1859.

Astacus saxatilis, Grube, Ein Ausflug nach Triest und dem Quarnero, p. 73, 1861.

Astacus saxatilis, Heller, Die Crustaceen des südlichen Europa, p. 217, Taf. VII. figs. 3, 5, 1863.

Astacus fontinalis (l'écrevisse à pieds blancs), Carbonnier, L'Écrevisse, p. 8, 1869.

Potamobius astacus, G. B. Sowerby, Continuation of Leach's Malacostraca Podophthalma Britanniæ, Nos. XVIII., XIX., Tab. XXXIV. fig. 1, 1875.

Astacus fluviatilis, Huxley,* The Crayfish, *passim*, and p. 230 in particular, Frontispiece and figs. 1–60, 1880.

Astacus torrentium, Huxley,* *op. cit.*, p. 296, fig. 61, a, d, g, fig. 62, a, d, 1880.

Astacus pallipes (der Dohlenkrebs), Klunzinger, Jahresh. Vereins vaterländ. Naturkunde Württemberg, XXXVIII. Jahrg., p. 341, 1882.

Astacus pallipes, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 154, 1884.

Under the name "Steinkrebs" the older authors appear to have confounded *A. torrentium* and *A. pallipes*. They were first separated as distinct species in 1858 by Lereboullet with the names *A. longicornis* and *A. pallipes*. Gerstfeldt (1859) seems to have had very little material from without the bounds of the Russian Empire. Of the "Steinkrebs" he had seen only five ill-preserved dried examples from the Rhone, which, as appears from his description of them (p. 577), belong to *A. pallipes*. He considers them to be the same species as that described by Schrank and Koch, i. e. *A. torrentium*. Compared with *A. torrentium*, *A. pallipes* has a narrower rostrum with a longer and narrower acumen; the median keel is more evident, especially near the tip of the rostrum; the antennæ are shorter, and the peduncle of the antennæ overreaches the tip of the rostrum by only a small fraction of the length of the terminal segment, while in *A. torrentium* it surpasses the rostrum by the whole length of the terminal segment; the longitudinal ridge on the lower face of the antennal scale is not toothed, as in *A. torrentium*; behind the cervical suture are several lateral spines; the chelæ are more coarsely and sparsely tuberculate. For a detailed comparison of these two species, see Klunzinger, *op. cit.*

A. pallipes and *A. torrentium* have a rudimentary pleurobranchia on each side of the penultimate and antepenultimate somites. In all the other species of Astacus which I have examined there is a third pair on the preceding somite. The first abdominal appendages of the male *A. pallipes* are figured by Brocchi, Ann. Sci. Nat., 6e Sér., Zool. et Paléontol., Tom. II., Pl. XIII. figs. 12, 13 ("*Astacus fluviatilis*" from Vaucluse). They agree in form

* Huxley leaves the question of the specific or the varietal value of the forms *A. nobilis* and *A. torrentium* (= *A. fluviatilis* and *A. pallipes*) undecided.

with those of *A. torrentium*, and differ from those of the other European species, as pointed out on page 140.

Distribution. — *Astacus pallipes* appears to be found chiefly in Southern and Western Europe. According to Kessler, it is not found in Russia. Grube collected it in Lake Vrana in the island of Cherso. Heller records it from Greece, Dalmatia, the island of Veglia, Trieste, Lake Garda, and Genoa. In France it is apparently common in the valley of the Rhone (I have seen specimens from Fontaine de Vaucluse and from Lyons),* and has perhaps passed from this valley into that of the Rhine, where it is known from Lake Neufchâtel (at Montagny and Neufchâtel), and from the neighborhood of Strasburg. In the last-named region *A. torrentium* and *A. fluviatilis* are also found (Lereboullet). The passage of the southern *A. pallipes* into Alsace would be facilitated by the Rhine and Rhone Canal, as Klunzinger has remarked.† According to the older authors, crayfishes are not found in Spain, but it is certain that at the present day the market of Madrid is supplied with a species of crayfish from the neighborhood of that city. "The crayfish appears to be unknown in the rivers Douro and Tagus on the western side of the Peninsula, and in the Ebro on the eastern; but it is found abundantly in the Talegones and Escalote, rivulets forming part of the sources of the Douro, in the Henares, one of the sources of the Tagus, and in the upper part of the Jalon, an important tributary of the Ebro. Widely separated, however, as these three rivers become in their courses to the sea, both east and west, the rivulets I have mentioned as forming their principal sources all take their rise within an area probably not more than twenty miles square, situated nearly in the centre of Spain, and about forty or fifty miles northeast of Madrid. It is from these small streams that the Madrid market is supplied, ... and these streams are the only ones well within the borders of the Peninsula in which, so far as I can discover, the crayfish is to be found. . . . . The peculiar localization of these crustaceans in the centre of Spain suggests the idea of their having been specially introduced, but experiments in acclimatization are, I believe, unknown in the Peninsula."‡

Huxley tells us (*op. cit.*, p. 298) that the crayfishes from the neighborhood

* Gerstfeldt's "Steinkrebs" from the Rhone (*op. cit.*, p. 577) is *A. pallipes*.

† In the collection of the Academy of Natural Sciences of Philadelphia are specimens from the Rhine (Dr. Hallowell) and from Paris (Guérin Coll., No. 284).

‡ Note on the Distribution of the Crayfish (Astacus) in Spain. By E. W. H. Holdsworth, F. L. S., F. Z. S., etc. Proc. Zoölog. Soc. London, 1880, pp. 421, 422.

of Madrid are "altogether similar to those of Britain [*A. pallipes*], except that the subrostral spine is less developed."

Crayfishes are also said to be found in the neighborhood of Barcelona, on the eastern coast of Spain (Gerstfeldt, *op. cit.*, p. 587). I cannot find any mention of them in Portugal.

Astacus pallipes also inhabits England and Ireland, in which it is probably the sole species. All the English and Irish specimens seen by Huxley belong to this species (Huxley, *op. cit.*, pp. 288, 298).* Bell's figure is certainly the same, and probably Pennant's as well, although concerning the latter there may be some doubt. According to Huxley, "They are abundant in some of our [English] rivers, such as the Isis and other affluents of the Thames; and they have been observed in those of Devon;† but they appear to be absent from many others. I cannot hear of any, for example, in the Cam or the Ouse, on the east, or in the rivers of Lancashire‡ and Cheshire, on the west. It is still more remarkable, that, according to the best information I can obtain, they are absent in the Severn, though they are plentiful in the Thames and Severn Canal. Dr. M'Intosh, who has paid particular attention to the fauna of Scotland, assures me that crayfish are unknown north of the Tweed."§

Crayfishes are found in many localities in Ireland, where they would seem to have been distributed to a greater or less extent by artificial means.‖ Perhaps they are not indigenous in any part of the island. Some remarks of Wm. Thompson¶ point to the existence of two species in Ireland (*A. fluviatilis* and *A. pallipes*?).

A. pallipes is a burrowing species, being found in the winter, according to Huxley, in holes in the banks of streams. The burrows may be more than a yard deep.** In the neighborhood of Strasburg it is found in holes in the canals (Lereboullet).

* *A. torrentium* of Huxley is *A. pallipes* Lereb.

† Moore, Mag. Nat. Hist., New Series, III. 289, 1839.

‡ There are specimens in the Museum of Comparative Zoölogy, from William Stimpson, said to have come from the neighborhood of Liverpool.

§ Huxley, *op. cit.*, p. 288.

‖ Wm. Thompson, "The Crustacea of Ireland," Ann. Mag. Nat. Hist., XI. 106, 1843.

¶ *Op. cit.*, p. 107, foot-note.

** Huxley, *op. cit.*, p. 8.

8. Astacus fluviatilis.

? *Cammarus*, Belon, De Aquatilibus, p. 353, fig. on p. 355, 1553.
Astacus fluviatilis, Rondelet, Universa Aquatilium Historia, Pars II. p. 210, with cut, 1555.
Astacus fluviatilis, Gesner, Historia Animalium, Lib. IV. p. 120, with cut, 1558. (In part. Edelkrebs, p. 122.)
Cammarus, Mattioli, Commentarii in Sex Libros Dioscoridis de Medica Materia, Lib. II. p. 309, with fig., 1565.
Cammarus, seu Astacus fluviatilis, Aldrovandi, De Reliq. Animal. Exang.: Moll. Crust. Testac. et Zoophyt., Cap. VI. p. 127, with cuts, 1606. (In part. Krebs, Edelkrebs, p. 129.)
Astacus fluviatilis (in part), Schonevelde, Ichthyologia, p. 24, 1624.
Gammarus seu Astacus fluviatilis, Worm, Museum Wormianum, p. 248, 1655.
Cammarus seu Astacus fluviatilis, Jonston, Hist. Nat. de Exang. Aquat., p. 18, Tab. II. fig. 4, Tab. III. figs. 2, 3, 4, Tab. IV. fig. 1 (fig. 2 after Aldrovandi), 1650. Also in Ruysch, Theatrum Univ. Animal., Pars IV. p. 15, Tab. II. fig. 4, Tab. III. figs. 2, 3, 4, Tab. IV. figs. 1, 2, 1718.
Gammarus seu Cancer fluviatilis, Sachs à Lowenheimb, Γαμμαρολογία, p. 204, Tab. VIII. (after Jonston), 1665.
Cancer macrourus; rostro supra serrato, basi utrinque dente simplici, Linné, Fauna Suecica, p. 358, 1746.
Der Flusskrebs, Rösel, Insekten-Belustigung, Th. III. p. 305, Tab. LIV.–LXI., 1755. (Figs. copied in Encycl. Méth., Vol. CXCI., Pl. 286, 288, 289, 290, 1830.)
Cancer astacus, Linné, Syst. Nat., 10th ed., I. 631, 1758; 12th ed., I. 1051, 1767.
Astacus fluviatilis, Fabricius, Syst. Entomol., p. 413, 1775. — Species Insectorum, I. 509, 1781. — Mantissa Insectorum, I. 331, 1787. — Entomol. Syst. emend. et aucta, II. 478, 1793. — Suppl. Entomol. Syst., p. 406, 1798.
Astacus fluviatilis, De Geer, Mém. pour serv. à l'Hist. des Insectes, Tom. VII., Pl. XX. — XXII., 1778.
Cancer astacus, Bock, Versuch einer wirthschaftlichen Naturgesch. von dem Königreich Ost- und Westpreussen, V. 278, 1785.
Cancer astacus, Herbst, Versuch einer Naturgeschichte der Krabben und Krebse, II. 38, Tab. XXIII. fig. 9, 1796. (In part. Edle Krebse, p. 41.)
Astacus fluviatilis, Latreille, Hist. Nat. gén. et partic. des Crustacés et des Insectes, I. 367, Pl. III., 1801; III. 33, 1801; V. 235, 1802. — Gen. Crust. et Insect., I. 51, 1806.
Astacus fluviatilis, Bosc, Hist. Nat. Crust., II. 62, Pl. XI. fig. 2, 1802.
Cancer nobilis (Edelkrebs), Schrank, Fauna Boica, III. 246, 1803.
Edelkrebs, Wolf, Mag. neuest. Zustand Naturkunde, Bd. XI., Taf. I. fig. 3, 1806.
Astacus fluviatilis, Lamarck, Hist. Nat. Anim. sans Vertèbres, V. 216, 1818.
Astacus fluviatilis, Desmarest, Consid. Gén. sur la Classe des Crustacés, p. 211, 1825.
Astacus fluviatilis, Brandt and Ratzeburg, Medizinische Zoologie, II. 58, Tab. X., XI., 1833.
Astacus fluviatilis (in part), Milne Edwards, Hist. Nat. Crust., II. 330, 1837. (Second "variety" noted on p. 331.)
Astacus fluviatilis, Koch, Deutschlands Crustaceen, Myriapoden und Arachniden, Heft 36, No. 23, with fig. (Panzer and Herrich-Schäffer's Deutschlands Insecten, Heft 186, No. 23), 1841.
Astacus fluviatilis, Erichson, Arch. Naturgesch., XII. Jahrg., I. 90, 1846.
Astacus fluviatilis, Lereboullet, Mém. Soc. Sci. Nat. Strasbourg, Tom. V., Pl III. figs. 1–1d, 1858.
Astacus fluviatilis communis, Gerstfeldt, Mém. Acad. Impér. Sci. St. Pétersbourg, IX. 554, 584, 1859.
Astacus fluviatilis, Heller, Die Crustaceen des südlichen Europa, p. 214, Taf. VII. fig. 4, 1863.
Astacus fluviatilis (l'écrevisse à pieds rouges), Carbonnier, L'Écrevisse, p. 8, 1869.
Astacus fluviatilis, Kessler, Bull. Soc. Impér. Nat. Moscou, XLVIII. 257 [357], 1874.
Astacus nobilis,* Huxley, The Crayfish, pp. 295, 296, fig. 61, B, E, H, fig. 62, B, E, 1880.
Astacus fluviatilis (Edelkrebs), Klunzinger, Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg, XXXVIII. Jahrg., p. 342, 1882.
Astacus fluviatilis, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 155, 1884.

Remarks on the Synonymy.—The above list comprises only the more important systematic works relating to *Astacus fluviatilis*. Works devoted exclusively to its anatomy, development, and physiology have been purposely omitted.

* See foot-note on page 143.

Under the name of *Astacus fluviatilis*, *Cammarus*, or *Gammarus*, the older authors included not only the "Edelkrebs," or the species to which the name *A. fluviatilis* is now restricted, but also the "Steinkrebs," or "Thulkrebs," a smaller form now known as *A. torrentium*. Indeed, it is probable that these authors confounded *A. torrentium* and *A. pallipes* under the one name "Steinkrebs."* As early as 1558 Gesner wrote: "Abundant Astaci fluviatiles in Helveticis et alpinis regionibus, in rivis, fluviis, torrentibus, lacubus. Sunt autem duorum generum: alii nobiles cognominantur (Edelkrebs), majores nigrioresque: alii Steinkrebs (id est saxatiles) et Thulkrebs (nescio unde dicuntur) reperiuntur in rivis saxosis, minores, parte supina albiores, prona nigriores; elixi non undiquaque rubescunt, sed partim albicant."†

Herbst (1796), in his account of *Cancer astacus*, not only discriminates between the Edelkrebs and the Steinkrebs, but mentions the large crayfish from the Volga and the Jaik, afterwards described as a distinct species by Eschscholtz under the name of *A. leptodactylus*.‡

In 1802 Schrank first separated the Steinkrebs and Edelkrebs as two distinct species, *Cancer torrentium* and *C. nobilis* (Fauna Boica, p. 246). The Russian *A. leptodactylus* was first named and described as a distinct species in 1823, by Eschscholtz (Mém. Soc. Impér. Nat. Moscou, Tom. V. p. 109, Tab. XVIII.). Fourteen years later, Milne Edwards, in the second volume of his classical "Histoire Naturelle des Crustacés," describes but one species of European Astacus (*A. fluviatilis*). He says, however: "Il existe deux variétés de cette écrevisse: dans l'une, le rostre se rétrécit graduellement dès sa base, et ses dents latérales sont situées près de son extrémité; dans l'autre, les bords latéraux du rostre sont parallèles dans leur moitié postérieure, et les dents latérales sont plus fortes et plus éloignées de son extrémité." The second so-called "variety" is *A. fluviatilis*. The first might be either *A. torrentium* or *A. pallipes*, for anything in the description, but the figure given by him in the Disciples' edition of Cuvier's Règne Animal is *A. pallipes*, which seems to be commoner in France than *A. torrentium*.

* The figures of the European crayfish in the older writers down to Pennant, as far as they can be determined, seem to represent *A. fluviatilis sensu strictiori*. Pennant's "Crawfish" is apparently *A. pallipes*. Of the figures published in the sixteenth and seventeenth centuries, those of Gesner and Mattioli, and Jonston's Tab. III. figs. 2, 3, 4, are tolerably good representations of the species.

† *Op. supra cit.*, p. 122. Cf. Aldrovandi, Schonevelde, Rösel, *ll. c.*, etc.

‡ So also Bose, *op cit.*, p. 38 (2d ed.): "Dans les grands fleuves de la Russie asiatique, tels que le Don, le Volga, etc., il y a des écrevisses d'une prodigieuse grandeur, qu'on ne pêche que pour avoir leurs pierres"; and on p. 40, under *Astacus fluviatilis*, "Se trouve dans les rivières en Europe *et en Asie*." So also Desmarest, *op. cit.*, p. 211, 1825.

In 1858 Lereboullet clearly pointed out the differences between the three species of Astacus inhabiting Western and Central Europe, viz. *A. fluviatilis*, *A. pallipes* (Dohlenkrebs), and *A. longicornis* (Steinkrebs). Lereboullet's *A. longicornis* is the species previously described by Schrank as *Cancer torrentium*.

In 1859 there was published a revision of the European Astaci by Gerstfeldt,* based chiefly upon the material in the Museum of the Imperial Academy of Sciences of St. Petersburg, and in the collection of the University of Dorpat. Gerstfeldt concludes that there are only two species of Astacus in Europe: *A. fluviatilis* (including four varieties, *A. fluviatilis communis*, *A. leptodactylus* Eschscholtz, *A. angulosus* Rathke, and *A. pachypus* Rathke) and *A. torrentium*, the "Steinkrebs." No one will deny that *A. fluviatilis*, *leptodactylus*, and *pachypus* are closely related to each other, but, judging from the material which I have examined, they constitute three species. It is true that some specimens of *A. fluviatilis* vary slightly in the direction of *A. leptodactylus*,† and *vice versa*, but not to such a degree as to bridge over the chasm between the two forms, or to puzzle even an untrained eye in separating them. I agree with Kessler in considering *A. fluviatilis*, *leptodactylus*, and *pachypus* to be distinct species.‡ *A. angulosus*, on the other hand, appears to pass by transitional forms into *A. leptodactylus*, and may be considered a local variety of the latter. Gerstfeldt's knowledge of the "Steinkrebs" was limited to five poorly preserved specimens from the Rhone River, which his description on page 577 shows to have been *A. pallipes* Lereb. He confounds this form with another species, the *Cancer torrentium* of Schrank.

Distribution. — Owing to the lack of discrimination on the part of most authors between the three species *A. fluviatilis*, *pallipes*, and *torrentium*, it is impossible accurately to determine the geographical range of these common European crayfishes, and the problem is further complicated by the artificial introduction of these animals as a food supply into many rivers to which they are not indigenous. *A. fluviatilis* alone among them is found within the limits of the Russian Empire. "Here it inhabits especially the Baltic watershed, where it reaches the northern as well as the eastern limit of its dis-

* Ueber die Flusskrebse Europa's. Von G. Gerstfeldt. Mém. Acad. Impér. Sci. St. Pétersbourg, Tom. IX.

† For example, in some specimens of *A. fluviatilis* the margins of the rostrum are slightly denticulate, and the fingers are longer than in the ordinary specimens.

‡ Kessler (*op. cit.*, p. 368) points out the fact, that in the Baltic area, where *A. leptodactylus* has invaded the domain of *A. fluviatilis*, no intercrossing of the two forms has taken place, but the former is driving out the latter.

tribution. Its extension in Finland, according to Nylander,* is bounded by a line passing from Christinestad, on the Gulf of Bothnia, southeasterly to Serdobol, at the northern end of Lake Ladoga. Eastward from Lake Ladoga it is found in the Uslanka, a tributary of the Sveer. It seems to be the sole occupant of the waters which flow from the south into the Gulf of Finland and the Baltic Sea, excepting the streams and lakes that are connected by means of canals with the basin of the Volga. In these it is partially replaced by *A. leptodactylus*. It still holds its own in Lakes Beresai and Bologoe, and in the small tributaries of the Msta and the Volkhov. Finally, it is found in some of the small streams of the upper part of the basin of the Dnieper as far as Moheelev."† According to Gerstfeldt (*op. cit.*, p. 558), *A. fluviatilis* sometimes passes out from the mouths of rivers into the sea, having been captured with marine fishes at a considerable distance from the shore on the coast of Livonia.

To the westward, *A. fluviatilis* extends into Austria, Germany, and France, dividing the field with *A. torrentium* and *A. pallipes*. It is difficult to determine its southern limits from the literature, on account of the uncertainty of the identification. If Scopoli's *Cancer astacus*‡ be this form, it is plentiful in Lake Kirknitz in Carniola. Belon (*op. cit.*, p. 353) speaks of crayfishes in the Po, and Olivi (Zoologia Adriatica, p. 48, 1792) gives "*Cancer astacus*" as one of the animals found in the neighborhood of Venice. Risso (Hist. Nat. Eur. Mérid., Tom. V. p. 55, 1826) records *A. fluviatilis* from the river Taggia, province of Porto Maurizio, and Costa includes it in his catalogue of the Crustacea of the kingdom of Naples (Fauna del Regno di Napoli, 1840). Heller, who distinguishes between *A. fluviatilis* and *A. pallipes*, gives as localities for the former, Nice, the Po, and Naples. Perhaps these localities are simply given on the authority of the older authors just enumerated; in which case, I suspect that the Italian crayfishes may turn out to be the

* Notzer ur Sällskap. pro Fauna et Flora Fennica. Förhandl. Ny Ser., Heft I. p. 248, 1859.

† Kessler, *op. cit.*, pp. 259, 260 [359, 360]. Gerstfeldt (*op. cit.*, p. 588) reports *A. fluviatilis* from Moscow, but perhaps it was brought there artificially for food, as it is more highly esteemed in this regard than its relative, *A. leptodactylus*. According to the same authority, there are two specimens of *A. fluviatilis* in the collection of Dorpat University, labelled *A. pachypus*, from Nicolaiev in Southern Russia (Boug River). It was formerly found in the Government of Koorsk (native or introduced?). See Köppen, Beitr. Kenntn. Russ. Reiches, 2te Folge, Bd. VI. pp. 297, 298. It was introduced into Southern Finland in the time of John III. of Sweden (1568–92). Middendorff, Sibirische Reise, Bd. IV. Th. 2, pp. 885, 886; Köppen, *op. cit.*, p. 297.

‡ Entomologia Carniolica, 1763. Cf. Gerstfeldt, *op. cit.*, p. 585, who thinks that the large specimens recorded from the river Kerka at Gurk may be *A. leptodactylus*. Heller, *op. cit.*, p. 215, also gives these Carniolian localities for *A. fluviatilis*, but whether from his own knowledge or on the authority of the older authors I cannot say.

commoner Southern species *A. pallipes*, which has been very generally confounded with *A. fluviatilis*.

The Astaci from the Spanish peninsula are probably *A. pallipes*, as well as those of England and Ireland.*

A. fluviatilis is also found in Denmark (Huxley, *op. cit.*, p. 299) and in the Scandinavian peninsula. It appears to have been introduced artificially into the latter, having been scarcely known in Sweden before the time of John III. (1568–92).† From Sweden it has spread into Southeastern Norway.‡

9. Astacus leptodactylus.

Astacus leptodactylus, Eschscholtz, Mém. Soc. Impér. Nat. Moscou, VI. 109, Tab. XVIII., 1823.
Astacus leptodactylus, Rathke, Mém. Acad. Impér. des Sci. St. Pétersbourg, III. 359, Tab. IV. figs. 1, 2, 1837. (Separate, 1836.)
Astacus leptodactylus, var. *Caspia*, Eichwald, Bull. Soc. Impér. Nat. Moscou, 1838, p. 148. — Fauna Caspio-Caucasia, p. 179, Tab. XXXVI. fig. 1, 1841.
Astacus leptodactylus, var. *salinus*, Nordmann, Observations sur la Faune Pontique, in Demidoff's Voyage dans la Russie Mérid. et la Crimée, Atlas, Crustacea, Tab. I. (No date.§)
Astacus leptodactylus, Ericuson, Arch. Naturgesch., XI. Jahrg., I. 90, 1846.
Astacus fluviatilis, var. *leptodactylus*, Gerstfeldt, Mém. Acad. Impér. des Sci. St. Pétersbourg, IX. 558, 584, 1859.
Astacus leptodactylus, Heller, Die Crustaceen des südlichen Europa, p. 215, Taf. VII. fig. 6, 1863.
Astacus leptodactylus, Kessler, Bull. Soc. Impér. Nat. Moscou, XLVIII. 249 [349], 1874.
Astacus leptodactylus, Huxley, The Crayfish, p. 303, fig. 75 (after Rathke), 1880.
Astacus leptodactylus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 157, 1884.

Var. angulosa.

Astacus angulosus, Rathke, Mém. Acad. Impér. des Sci. St. Pétersbourg, III. 364, Tab. IV. fig. 3, 1837. (Separate, 1836.)
Astacus angulosus, Ericuson, Arch. Naturgesch., XI. Jahrg., I. 91, 1846. (After Rathke.)
Astacus fluviatilis, var. *angulosus*, Gerstfeldt, Mém. Acad. Impér. des Sci. St. Pétersbourg, IX. 563, 584, 1859.
Astacus angulosus, Heller, Die Crustaceen des südlichen Europa, p. 216, 1863.
Astacus leptodactylus, var. *angulosus*, Kessler, Bull. Soc. Impér. Nat. Moscou, XLVIII. 251 [351], 1874.
Astacus leptodactylus, var. *angulosa*, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 157, 1884.

Distribution. — *Astacus leptodactylus* has the widest distribution of any of the European species of Astacus. It is found in all the rivers that flow into the Black Sea and the Sea of Azov on the north from the Danube to Mount Caucasus, and in those that empty into the Caspian Sea as far east as the Ural Mountains and the Muchojar Hills in Western Siberia. It descends into the brackish waters of the estuaries of the rivers that empty into the Black

* See pp. 144, 145.
† Linné, Fauna Succica, p. 358, 1746.
‡ G. O. Sars, Hist. Nat. des Crustacés d'Eau douce de Norvège, p. 11, 1867.
§ The text is dated 1840.

Sea and the Sea of Azov, and it is widely distributed in the Caspian Sea, having been reported from the following points therein: Peninsula of Manghishlak, Island of Cheleken, Krasnovodsk, Astrabad, Sara Island, Lenkoran, and Bakoo (Kessler, Eichwald). It has been taken with the dredge from a depth of six to nineteen fathoms in the Caspian Sea (Kessler, p. 372). I have seen specimens from the basin of the Danube as far up as Balaton Lake * in Hungary (Coll. Peabody Mus. Yale Coll.), and Heller reports it from the Theiss River and Mohacs. Middendorff states that it ascends the Volga system to the sixtieth parallel, in the neighborhood of Tcherdy.† It is also found to the northward in the rivers and lakes which drain into the Baltic and White Seas, Erichson reporting it from Courland,‡ Kessler from many of the lakes and rivers that connect with the Gulf of Finland; viz. Lakes Ilmen and Valdai, and the rivers Vodla, Vytegra, Sveer, Volkhov, and Msta.§ Here it has invaded the domain of *A. fluviatilis*, and according to Kessler is supplanting that less fertile species.‖ In the Northern Dwina *A. leptodactylus* alone is found, descending to Archangel.**

The Ponto-Caspian basin is undoubtedly the original home of *A. leptodactylus*. Thence its migration into the northern rivers was made easy by the canals connecting the Volga and Dnieper with the rivers of the Baltic and White Seas.

A. leptodactylus was introduced by man in 1822 into the River Isset, a tributary of the Tobol, in Western Siberia, and is now common in many of the streams of the Obi River basin, e. g. the Toora, Niza, Irtish, Tara, Om, and also in the upper part of the Obi. Its distribution over such a wide area of the Obi basin is due partly to spontaneous spreading, partly to artificial transference from one stream to another. It is probable that crayfishes did not exist in the waters east of the Ural Mountains until they were transported thither by man, although Pallas †† speaks of their presence in the upper course of the Ui, an affluent of the Tobol, as early as 1770. As the

* The water of Balaton Lake is said to be slightly salt.

† Sibirische Reise, Bd. IV. Th. 2, p. 882, 1867.

‡ Kessler (*op. cit.* p. 253 [353]) doubts whether *A. leptodactylus* be found in Courland, as Erichson announced; but as the Southern Dwina is connected by means of canals with both Lake Ilmen and the Beresina River (an affluent of the Dnieper), immigration of this species into Courland would be facilitated.

§ The Msta, which flows into Lake Ilmen, and thence through Lake Ladoga into the Gulf of Finland, is connected by a canal with the Tvertsa, a tributary of the Volga. The Vytegra also communicates with the basin of the Volga through the Mariuskoi Canal.

‖ According to Kessler *A. leptodactylus* lays from 500 to 600 eggs, *A. fluviatilis* rarely more than 250.

** *A. leptodactylus* is also found in Lapland, according to Gerstfeldt, *op. cit.*, p. 589.

†† Reise durch verschiedene Provinzen des Russischen Reiches, Th. II. p. 381.

sources of the Ural River are not remote from those of the Ui, it is possible that a spontaneous migration from the former into the latter has taken place.*

Eichwald describes and figures *A. leptodactylus*, var. *Caspia*, from the Caspian Sea near Lenkoran, as smaller than the normal form, the carapace smoother, and the margins of the rostrum nearly smooth. It is probably an immature stage of *A. leptodactylus*.

In *Astacus angulosus* Rathke, from the Crimea and adjacent region, the fingers of the male are not elongated, as in *Astacus leptodactylus* Eschscholtz, so that the hand has much the same form as in the female of the latter species. The rostrum, moreover, is broader, with its margins more nearly parallel from the base to the lateral spines, and with its median carina prominent and toothed toward the apex; the abdominal pleura are shorter and broader than in *A. leptodactylus*. The flattening of the sides of the carapace, by which an angle is formed by the dorsal and lateral faces, is not characteristic of this form, although it suggested the name to Rathke. The same condition is sometimes found in specimens that in all other respects agree with the form *leptodactylus*, while in some examples of *A. angulosus* the branchial regions are as convex as in *A. leptodactylus*. In the shape of the rostrum and abdominal pleura *A. angulosus* approaches *A. fluviatilis*, but it cannot be confused with that species, on account of the shape of the chela, the double pair of post-orbital spines, etc. Forms intermediate between *A. angulosus* and *A. leptodactylus*, having the rostrum of the latter combined with characters belonging to the former, are met with in the Sulak River, which flows into the Caspian south of the Terek on the northern side of Mount Caucasus (Gerstfeldt). It seems natural, therefore, to consider *A. angulosus* a variety of *A. leptodactylus*.

Since this account of the European Astaci was written, Wladimir Schimkewitsch† has published an insufficient preliminary notice of an Astacus from the neighborhood of the town of Turkestan in the valley of the Jaxartes. It is closely related to *A. fluviatilis* and *A. leptodactylus*, perhaps not specifically distinct from one of these. It seems to be subject to considerable variation in the form of the rostrum and telson. According to Schimkewitsch it differs from all the allied species in the great development of spiny tubercles on the sides of the carapace (there being four on the hind border of the cervical

* With reference to the presence of *A. leptodactylus* in Western Siberia, see Kessler, *op. cit.*, p. 371, Middendorff, *op. cit.*, p. 885, and especially Köppen, "Notiz über die Rückwanderung der *Dreissena polymorpha* Pall. Nebst einem Anhange: Ueber künstliche Verpflanzung der Flusskrebse in Russland." Beitr. zur Kenntniss des Russischen Reiches, 2te Folge, Bd. VI., 1883.

† Der turkestanische Flusskrebs. (Vorläufige Mittheilung.) Von Wladimir Schimkewitsch. Zoologischer Anzeiger, VII. 339–341, 23 Juni, 1884.

groove on each side of the body) and in the shape of the anterior process of the epistoma, which is triangular with convex sides. It would seem to approach *A. angulosus* in the spiny character of the carapace. Schimkewitsch affirms that intermediate forms connect *A. pachypus* with *A. leptodactylus* (Government of Riazan), and *A. leptodactylus* with *A. fluviatilis* (Governments of Toola and Moscow). He evidently inclines, with Gerstfeldt, to the opinion that all the Eurasiatic Astaci, excepting those of the Amoor basin and Japan, form but two distinct species, viz. *A. nobilis* (including the varieties *A. fluviatilis, leptodactylus, angulosus, pachypus, Colchicus,* etc.) and *A. torrentium* (including *A. pallipes*) of Western Europe. In the material that has fallen into my hands I have not seen indications of the intermediate forms, and I have been led to consider all the forms just named to be valid species, with the exception of *A. angulosus.* Kessler, who had unrivalled opportunities for forming a just opinion on this point, came to the same conclusion. After all, to any one who believes that all these forms are descended from a common ancestor, the question whether they constitute two species with marked varieties, or whether they rather form two groups of closely allied species, is merely a question of terms.

10. Astacus pachypus.

Astacus pachypus, Rathke, Mém. Acad. Impér. Sci. St. Pétersbourg, III. 365, 1837. (Separate, 1836.)
Astacus Caspius, Eichwald, Bull. Soc. Impér. Nat. Moscou, 1838, p. 149. — Fauna Caspio-Caucasia, p. 181, Tab. XXXVI. fig. 2, 1841.
Astacus pachypus, Erichson, Arch. Naturgesch., XII. Jahrg., I. 91, 1846. (After Rathke.)
Astacus Caspius, Erichson, *op. cit.*, p. 92, 1846. (After Eichwald.)
Astacus fluviatilis, var. *pachypus et Caspius*, Gerstfeldt, Mém. Acad. Impér. Sci. St. Pétersbourg, IX. 566, 584, 1859.
Astacus pachypus, Heller, Die Crustaceen des südlichen Europa, p. 217, 1863.
Astacus pachypus, Kessler, Bull. Soc. Impér. Nat. Moscou, XLVIII. 254 [354], 1874.
Astacus pachypus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 158, 1884.

Distribution. — Brackish waters of the Caspian Sea and estuaries of rivers flowing into the Caspian and Black Seas. Estuary of the Dniester at Kologlea (Kessler); of the Boug at Nicolaiev (Rathke, Kessler); mouths of the Volga, Astrakhan (Kessler); Lesser Oozen River; Caspian Sea at Manghishlak (Kessler), Krasnovodsk (Kessler), and Bakoo.

11. Astacus Colchicus.

Astacus Colchicus, Kessler, Bull. Soc. Impér. Nat. Moscou, L. 2, 1876.
Astacus Colchicus, Faxon, Proc. Amer. Acad. Arts and Sci., XX. 158, 1884.

Distribution. — Upper part of Rion River and tributaries, Transcaucasia. According to Kessler, Astaci are found in Lake Palæostom, south of the mouth of the Rion; but whether they be *A. Colchicus* or not is unknown. *A. Colchicus* is brought to the market of Tiflis from the upper Rion. It has

been artificially introduced, according to Dr. Radde, into some of the tributaries of the upper Koor (the Cyrus of the ancients), which flows eastward into the Caspian Sea (Kessler).

NOTE ON THE FOSSIL ASTACIDÆ.

Abundant fossil remains of Crustacea nearly allied to the recent Homaridæ and Astacidæ are found in the Jurassic from the Middle Lias to the lithographic slates of Bavaria and Würtemberg. These ancient Decapods, belonging to the genera Eryma and Pseudastacus,* agreed with the lobsters and crayfishes of the present day in having the three anterior pairs of legs terminated by pincer-like claws (the first pair large and powerful), the abdominal pleura drawn out into prominent lateral plates, and the outer branch of the enlarged posterior pair of appendages or swimmerets divided by a transverse suture. The carapace was produced into a prominent rostrum, commonly denticulate on the margin; the telson showed no trace of a division into two pieces by a transverse suture (agreeing in this regard with the telson of the modern Homaridæ and Parastacinæ), and was more triangular in outline than in the living forms; the large chelæ were nearly symmetrical on the two sides of the body, and the shell granulated or tuberculated, as in the Astacidæ. If we unite the Homaridæ and the Astacidæ in one tribe, the Astacoidea, there can be no reasonable doubt that the Jurassic genera Eryma and Pseudastacus would be included properly in this tribe. To them we turn in seeking the progenitors of the Homaridæ and Astacidæ of our seas and rivers. Unfortunately, these fossils have imparted as yet no information concerning certain important structural features which must be known before we can determine whether the Astacine type was thus early differentiated from the Homarine. I refer to the number, structure, and arrangement of the gills; the condition of the last thoracic somite, whether free or fixed; and the structure of the anterior abdominal appendages. In our ignorance of these structural characters in these marine Jurassic fossils I cannot see the slightest ground for Huxley's conclusion, that in the genus Pseudastacus we already see a differentiation of the Astacine from the Homarine type represented by Eryma.† Pseudastacus differs from Eryma in having a longer rostrum, longer and thicker antennal peduncle and scale, and in the lack of movable spines on the penultimate segment of the fourth pair of legs. In *P. pustulosus* (Münst.) the inner as well as the outer branch of the swimmerets seems to have been divided by a transverse suture. Now, in none of these particulars does Pseudastacus, as distinguished from Eryma, approach the Astacidæ of the present time. Boas‡ has called attention to the fact that the transverse part of the "cervical" groove of Pseudastacus is the same as the anterior and more deeply impressed groove (marked *c'* in Boas's figures) on the carapace of Eryma, and that it is not homologous with the cervical groove of Homarus and Astacus (*c* of Boas's figures), but rather with the anterior slightly impressed groove seen on the carapace of Nephrops.

* For an account of these animals, the reader is referred to the beautifully illustrated work of Oppel, Palæontologische Mittheilungen, Stuttgart, 1862. The *Astacus Knorrii* of Milne Edwards (Hist. Nat. Crust., II. 333), figured by Knorr and by Desmarest, is probably an Eryma.

† Huxley, The Crayfish, p. 343.

‡ Studier over Decapodernes Slægtskabsforhold. Vidensk. Selsk. Skr., 6te Række, Naturvid. og Math. Afd., Bd. I. pp. 74, 176, foot-note 2, 1880.

No remains of Crustacea near the Astacidæ have been found in the Wealden, which is of fresh-water origin, while the Cretaceous has yielded the genera Hoploparia and Enoploclytia, which closely resemble the recent Homaridæ. Hoploparia is found also in the London Clay (Eocene).

Schlüter* has described, under the name *Astacus politus*, a Decapod from the Lower Chalk of Westphalia, in which the telson is divided by a transverse suture, as in the majority of the Potamobiinæ; but the single specimen obtained is too imperfect to admit of being definitely placed, the fore part of the carapace, including the rostrum, as well as the terminal portion of all the legs, being lost.†

It is only in the fresh-water Tertiary deposits of the Western United States that fossils have been discovered which can be referred reasonably to the family Astacidæ. Packard‡ has described and figured by the name of *Cambarus primævus* two specimens from the Lower Tertiary beds (Eocene?) of the Bear River Valley in Western Wyoming. Judging from Packard's figures, I should think that these specimens belonged to Astacus rather than to Cambarus. The shape of the antennal scale and the chelæ indicate this. I fail to see the close resemblance pointed out by Packard between these specimens and *Cambarus affinis*. The rostrum, as shown in the figures, resembles that of *A. Dauricus* as nearly as any living form. With reference to the conditions under which these crayfishes lived, Dr. Packard says: "The soft, fine, fissile, clayey shales of the Bear River Tertiaries contain not only a good many herring-like fish, but also genuine skates. The presence of land plants mingled with marine animals shows that the waters were fresh, but communicated with the sea; the conditions were apparently those of a deep estuary, into which fresh-water streams ran, and in these rivers lived the crayfish. The deposits were probably Eocene, if these divisions are to be retained for the Tertiary deposits of the West, and may have been laid down nearer the ocean than those of Green River."

In 1870 Cope§ described three extinct species of Astacus from fresh-water Tertiary deposits in the Territory of Idaho. The specimens were obtained by Clarence King, on the expedition sent out for the geological exploration of the fortieth parallel west of the Mississippi River. I have not been able to find the specimens in the Smithsonian Institution, where they belong.

The first species described by Cope is named *Astacus subgrundialis*. In this form the rostrum is narrow, concave above, acute, with five spinous points on each side and a terminal recurved spinelet; two post-orbital tubercles on each side, the anterior pair spiniform; surface of the carapace smooth or obsoletely wrinkled; abdominal pleura prominent and acuminate, those of the second segment four times as wide as the others; chelæ nearly smooth, not granulate, the superior edge spiniferous; the longitudinal groove of the carpus is well marked, and this segment is not spiniferous; the antennal scales are large, and extend nearly to the tip of the rostrum; areola of moderate width. Length to cervical

* Neue Fische und Krebse aus der Kreide von Westphalen. Von Dr. W. von der Marck und Dr. Cl. Schlüter. Palæontographica, XV. 302, Taf. XLIV. figs. 4, 5, 1868.

† So also with the genus Astacodes founded by Bell (Mon. Foss. Malacostr. Crust. Great Britain, Pt. II. Crust. of the Gault and Greensand, p. 30, Pl. IX. figs. 1–6, 1862) for the reception of *Meyeria falcifer* Phillips from the Speeton Clay.

‡ "Fossil Crawfish from the Tertiaries of Wyoming," Amer. Nat., XIV. 222, 223, March, 1880. "On a Crayfish from the Lower Tertiary Beds of Western Wyoming," Bull. U. S. Geolog. and Geograph. Surv. Terr., VI. 391–397, with two cuts, September, 1881.

§ "On Three Extinct Astaci from the Fresh-water Tertiary of Idaho," Proc. Amer. Philosoph. Soc., XI. 605–607, 1870.

groove, .0415 m.; of rostrum, .0182 m.; of abdomen, .072 m. From near Hot Spring Mountain.

The second species is named *Astacus chenoderma*. "This species is represented by the cheles of opposite sides of one individual, with which I associate with great probability one from the right side of a second. Part of a cephalothorax of a third is associated, but without conclusive evidence of identity, chiefly because of a near resemblance in the sculpture." The chelæ are long and slender, without spinous armature, but covered with thickly set granular tubercles. In the second specimen part of the carpus is preserved; its lower margin is unarmed, while the outer face presents a series of short, distantly placed spines. The surface of the carapace, as seen in the third specimen, is delicately wrinkled by the confluent bases of fine pointed granules, which are directed forward; these become more scattered on the sides. As in *A. subgrundialis*, there are two pairs of post-orbital spines. The areola is of moderate width. Length from rostrum to cervical groove, .0235 m. Width of areola .25 inch from front, .007 m. Length of chela, .045 m. Width of base of chela, .0173 m. From Catharine's Creek.

The third species, *Astacus breviforceps*, is "established primarily on three cheles or last segments of the fore limbs; with these I have associated a cephalothorax of one, and abdominal and postabdominal regions of three individuals. The only reason for such reference of the latter is their superficial texture, in which they resemble the cheles, and differ from the corresponding parts in the two other species." The chelæ are short, thick, the lower edge thin, the index rather short and conical; the surface of the chelæ is granular tuberculate, except on the convex faces, where it is finely vermiculate rugose. "The cephalothorax associated is quite similar to that of *A. subgrundialis*, and may possibly belong to it. It however differs in the finely vermiculate rugose character of its surface. The rugæ are generally transverse on the back and sides." The upper surface of the abbominal segments is marked with a delicate vermiculate rugosity, like that of the cephalothorax. In *A. subgrundialis* it is marked with impressed dots. The pleura of the second abdominal somite are less than twice the width of the succeeding ones, instead of being four times as wide, as in *A. subgrundialis*. The succeeding pleura are long, pointed, and slightly curved forward. "Some of the specimens indicate individuals larger than those referred to *A. subgrundialis*." From Catharine's Creek.

According to Professor Cope, the beds in which these fossils were found are of freshwater lacustrine origin, as determined by the fishes and mollusks found therein. As to their age, there is "great probability of their being later than the Miocene, and nothing to conflict with their determination as of Pliocene age." *

Although nothing is known concerning the gills, or the presence or absence of hooks on the legs, I am disposed to regard the fragments described by Cope as remains of true Astaci, on account of certain superficial characters, such as the denticulate rostrum, the post-orbital tubercles, the prominent acuminate abdominal pleura, etc. The only Astacus known to inhabit the Territory of Idaho at the present day is *A. Gambelii*. Cope himself has pointed out the resemblance of the rostrum of *A. subgrundialis* to that of *A. Gambelii*, and I have already shown (p. 131) that in the structure of the gills the last-named species approaches the primitive type more nearly than any other living Astacus. In the elongated, acuminate abdominal pleura, and in the two pairs of post-orbital tubercles, the fossil species more nearly resemble *C. nigrescens*.

* Cope, *ibid.*, p. 547.

Table showing the Geographical Distribution of every Species of Cambarus and Astacus as far as yet ascertained.

Genus CAMBARUS.

Group I.

1. **C. Blandingii.**
   New York.
   New Jersey: Essex Co.; Delaware River and tributaries near Trenton, Mercer Co.
   Maryland: Baltimore Co.; Caroline Co.; Dorchester Co.; St. Mary's Co.; Somerset Co.; Wicomico Co.; Worcester Co.
   Virginia: James River; Lunenburg.
   North Carolina: Tarboro; tributaries of Neuse River, Goldsboro; Kinston; Beaufort; Salmon Creek; Wilmington.
   South Carolina: Camden; Saluda River; Columbia.
   Georgia: Richmond Co.

   Var. **acuta.**
   South Carolina: Charleston; Beaufort.
   Alabama: Mobile; Blount Spring, Blount Co.; Cullman, Cullman Co.; Decatur, Morgan Co.; overflow of Tennessee River, near Bridgeport, Jackson Co.
   Mississippi: tributary of Tombigbee River, Kemper Co.; near Vicksburg.
   Louisiana: Tickfaw; Amite City; New Orleans.
   Tennessee: Memphis.
   Missouri: St. Louis.
   Illinois: Athens; Decatur; Pekin; Normal; Oquawka; Peoria; Lawn Ridge; Evanston.
   Indiana: Wheatland, Knox Co.
   Iowa: West Liberty; Dubuque.
   Wisconsin: Racine; Sauk City.

2. **C. fallax.**
   Florida: St. John's River at Jacksonville, Orange Bluff, Hawkinsville, Horse Landing, Blue Spring, and Lake Jessup; Magnolia; Indian River; Titusville, Brevard Co.

3. **C. Hayi.**
   Mississippi: Macon; Artesia.

4. **C. Clarkii.**
   Texas: between San Antonio and El Paso del Norte; San Antonio: Waller Co.
   Louisiana: New Orleans; Tangipahoa River.
   Mississippi: Ocean Springs, Jackson Co.
   Alabama: Mobile.
   Florida: Pensacola; three miles below Horse Landing, St. John's River.

5. **C. troglodytes.**
   Georgia: Richmond Co.
   South Carolina: Charleston; Oakley; Columbia.

6. **C. maniculatus.**
   Georgia: in ditches in the lower part of the State. (Le Conte.)
7. **C. Lecontei.**
   Alabama: Mobile.
   Georgia: Athens.
8. **C. angustatus.**
   Georgia: lower part of the State. (Le Conte.)
9. **C. pubescens.**
   Georgia: Richmond Co.
10. **C. spiculifer.**
    Georgia: Athens; Milledgeville; Atlanta; Roswell, Cobb Co.; Chattahoochee River, Gainesville; Etowah River.
11. **C. versutus.**
    Alabama: neighborhood of Mobile.
    Florida: Cape Barrancas. (See page 34.)
12. **C. Alleni.**
    Florida: St. John's River, Hawkinsville; Hernando Co. (See page 36.)
13. **C. penicillatus.**
    Georgia.
    ? Mississippi. (See page 37.)
    ? South Carolina: Charleston. (See page 37.)
14. **C. Wiegmanni.**
    Mexico.
15. **C. pellucidus.**
    Kentucky: Mammoth Cave and other caves in Edmonson Co.
    Indiana: Wyandotte Cave; cave in Bradford, Harrison Co.

GROUP II.

16. **C. simulans.**
    Texas: Dallas; east of Canadian River.
    Kansas: Fort Hays.
17. **C. advena.**
    Georgia.
18. **C. Carolinus.**
    South Carolina: Charleston; Greenville? (See page 56.)
19. **C. gracilis.**
    Illinois: Normal; Lawn Ridge; Athens.
    Wisconsin: Racine.
    Iowa: Davenport.
20. **C. Mexicanus.**
    Mexico.
21. **C. Cubensis.**
    Cuba: near Havana.

GROUP III.

22. **C. Bartonii.**
    Dominion of Canada: St. John, New Brunswick; Montreal?
    Maine: Houlton and Maysville, Aroostook Co.; Madison, Somerset Co. (See p. 62.)

Vermont: Burlington, Colchester, and Shelburne, Chittenden Co.

Massachusetts: Grafton, Worcester Co.; Williamstown, Berkshire Co.

New York: Lake Champlain; Ellenburg, Clinton Co.; Westport and Elizabethtown, Essex Co.; Fulton Lakes, Hamilton and Herkimer Cos.; Canton, St. Lawrence Co.; Port Jervis and Newburg, Orange Co.; Fishkill, Duchess Co.; Fallsburg, Sullivan Co.; Sherburne, Chenango Co.; Cazenovia, Madison Co.; Ithaca, Tompkins Co.; Berkshire, Tioga Co.; Genesee River, Rochester, Monroe Co.; Niagara, Niagara Co.; Forestville, Chautauqua Co.

New Jersey: Schooley's Mountain; Orange; Trenton.

Pennsylvania: Bedford and Pattonville, Bedford Co.; Windham, Bradford Co.; Hummelstown, Dauphin Co.; Carlisle, Cumberland Co.; Berwick, Columbia Co.; Bainbridge, Lancaster Co.; Schuylkill River, near Philadelphia; Chester Co.; McKean Co.; Foxburg, Clarion Co.

Maryland: Harford Co.; Howard Co.; Montgomery Co.; Frederick Co.; Washington Co.; Garrett Co.; Alleghany Co.

District of Columbia: Rock Creek, Georgetown.

Virginia: Clarke Co.; Alexandria Co.; Franklin, Southampton Co.; tributaries of Rappahannock River, Stafford Co.; James River; tributaries of James River, Rockbridge Co.; Lunenburg, Lunenburg Co.; Bath Co.; Reed Creek, west of Wytheville, Wythe Co.; Holston River, Smyth Co.

West Virginia: Williamsport, Grant Co.; South Branch of Potomac River; Patterson's Creek; Petroleum, Ritchie Co.; near White Sulphur Springs, Greenbrier Co.; branch of Clinch River, northern base of Clinch Mountains.

North Carolina: Kinston; Newman's Fork, Blue Ridge, McDowell Co.

Ohio: Marietta; Cincinnati; Yellow Springs; Scioto River, Columbus.

Indiana: New Albany; Fall Creek, Indianapolis.

Lake Superior.

Kentucky: Cumberland Gap, Josh Bell Co.; Smoky Creek, Carter Co.; Kentucky River, Little Hickman, Jessamine Co.; Bear Creek, Grayson's Springs, Grayson Co.; Mammoth Cave, Edmonson Co.

Tennessee: Doe River, Carter Co.; Lineville Cave, near Blountsville, Sullivan Co.; Knoxville.

For doubtful localities for *C. Bartonii*, see page 63.

VAR. **robusta**.

Dominion of Canada: Humber River and Don River, Toronto; Indian Creek, Weston, Province of Ontario.

New York: Forestville, Chautauqua Co.; Genesee River, Rochester, Monroe Co.; Sodus, Wayne Co.; tributary of Racket River, near Tupper's Lake, St. Lawrence Co.; Canton, St. Lawrence Co.; Fulton Lakes, Hamilton and Herkimer Cos.; Natural Bridge, Jefferson Co.

Maryland: Montgomery Co.

Virginia: Fredericksburg.

Illinois: Decatur.

23. **C. acuminatus**.

South Carolina: Saluda River.

24. **C. latimanus**.

South Carolina: Columbia; Greenville.

Georgia: Athens; Milledgeville; Roswell.

Alabama: Blount Spring and Cullman, Sand Mountain; Bridgeport. (See page 69.)
Mississippi: Ocean City.
Tennessee: Ashland City, Cheatham Co. (See page 69.)

25. **C. Diogenes.**
New Jersey: Hamilton Township, Mercer Co.
Pennsylvania: Derry Station, Westmoreland Co.
Maryland: Baltimore Co.; St. Mary's Co.; Caroline Co.; Dorchester Co.; Worcester Co.; Garrett Co.
District of Columbia: near Washington.
Virginia: Alexandria Co.; Accomack Co.; Northampton Co.; Fredericksburg, Spottsylvania Co.; Petersburg, Dinwiddie Co.
North Carolina: Wilmington; Kinston.
Ohio: Kelley's Island, Lake Erie.
Indiana: Long Lake, Kendallville, Noble Co.; Mechanicsburg, Henry Co.; Knox Co.
Illinois: Lawn Ridge; Evanston; Belleville; Decatur; Chicago; Abingdon.
Michigan: Detroit.
Wisconsin: tributary of Pecatonica River, Green Co.; Appleton; Racine.
Iowa: Davenport.
Missouri: Carroll Co.; St. Louis.
Kansas: Leavenworth.
Colorado: Clear Lake.
Wyoming: Cheyenne.
Arkansas.
? Kentucky.
? Tennessee.
Mississippi: Monticello, Lawrence Co.
Louisiana: New Orleans.

26. **C. argillicola.**
Dominion of Canada: Toronto, Province of Ontario.
Michigan: Detroit; East Saginaw.
Indiana: New Albany.

27. **C. dubius.**
Virginia: Pennington's Gap, Lee Co.
West Virginia: Cranberry Summit, Preston Co.
Tennessee: Cumberland Gap.

28. **C. Nebrascensis.**
Dakota: Fort Pierre. (Girard.)

29. **C. Uhleri.**
Maryland: Caroline Co.; Dorchester Co.; Talbot Co.; St. Mary's Co.; Wicomico Co.; Somerset Co.; Worcester Co.

30. **C. extraneus.**
Georgia: Etowah River, Rome.
Tennessee: Tennessee River, near border of Georgia.

31. **C. Girardianus.**
Alabama: Cypress Creek, Lauderdale Co.

32. **C Jordani.**
Georgia: Etowah River, Rome.

33. **C. cornutus.**
Kentucky: Green River, near Mammoth Cave.

34. **C. hamulatus.**
Tennessee: Nickajack Cave.

GROUP IV.

35. **C. medius.**
Missouri: Irondale, Washington Co.

36. **C. immunis.**
New York.
Indiana: White River; Fall Creek, Indianapolis; Long Lake, Kendallville.
Illinois: Aux Plains; Belleville; Lawn Ridge; Normal; Oquawka.
Michigan: Detroit River, Detroit.
Wisconsin: Milwaukee.
Minnesota: Richfield, Hennepin Co.
Iowa: West Liberty.
Missouri: St. Louis.
Kansas: Leavenworth; Ellis.
Wyoming: near Laramie.
Alabama: Huntsville.
Mexico: Orizaba.

VAR. **spinirostris.**
Tennessee: Obion Co.

37. **C. Mississippiensis.**
Mississippi: Macon.

38. **C. Palmeri.**
Tennessee: Obion Co.

39. **C. Alabamensis.**
Alabama: Waterloo, Lauderdale Co.

40. **C. compressus.**
Alabama: Lauderdale Co.

41. **C. lancifer.**
Mississippi: Root Pond.

42. **C. affinis.**
New York: Niagara.
New Jersey: Schooley's Mountain and Dover, Morris Co.; Red Bank, Monmouth Co.; Trenton, Mercer Co.; Camden Co.
Pennsylvania: Brandywine Creek; Schuylkill; Reading; Philadelphia; Bristol; Susquehanna River; Bainbridge; Carlisle.
Maryland: Cecil Co.; Harford Co.; Havre de Grace; Baltimore Co.; Anne Arundel Co.; Montgomery Co.; Potomac River, Charles Co.; Williamsport, Washington Co.; Cumberland, Alleghany Co.
District of Columbia: Potomac River, Washington.
Virginia: Potomac River, Gunston, Fairfax Co.
? Lake Erie.
? Lake Superior.

43. **C. Sloanii.**

Indiana: New Albany.

Kentucky. (Bundy.)

44. **C. propinquus.**

Dominion of Canada: Montreal; Toronto.

New York: Grass River, Black Lake, and Canton, St. Lawrence Co.; Ogdensburg; Lake Ontario; Garrison Creek, Sackett's Harbor; Four-Mile Creek, Oswego; Oneida Lake; Cayuga Lake; Rochester; Niagara; Forestville, Chautauqua Co. All of these localities are in the St. Lawrence River system.

Indiana: Elkhart River, Rome City, Noble Co.; Delphi; Indianapolis; Michigan City; Turman Creek, Sullivan Co.; Clear Creek, Bloomington; White River; Switz City.

Illinois: Freeport, Stephenson Co.; Ogle Co.; Geneva, Kane Co.; Pekin, Tazewell Co.; Normal, McLean Co.; Decatur, Macon Co.; Aux Plains River.

Michigan: St. Clair River; Detroit River; Northville; Huron River, Ann Arbor; Ecorse; Kalamazoo River, Otsego.

Lake Superior.

Wisconsin: tributaries of Pecatonica River, Green Co.; Madison.

Iowa: Davenport; Des Moines River, Ottumwa.

VAR. **Sanbornii.**

Kentucky: Smoky Creek, Carter Co.

Ohio: Oberlin.

VAR. **obscura.**

New York: Genesee River, Rochester.

45. **C. Harrisonii.**

Missouri: Irondale, Washington Co.

46. **C. virilis.**

Dominion of Canada: Lake Winnipeg; Saskatchewan River; Red River of the North; Toronto; Montreal?

Dakota: Red River of the North, near Pembina; Souris or Mouse River.

Minnesota: Lake Superior; Mississippi River; Lake Minnetonka, Minnehaha Creek, Cedar Lake, Bassett's Creek, and Lake Independence, Hennepin Co.

Wisconsin: Appleton; Baraboo River, Ironton; Sauk City; Wisconsin River; Sugar River; Rock River; Jefferson; Milwaukee.

Iowa: Davenport; Burlington; Fort Dodge; Spring Vale; Des Moines River; Bedford.

Nebraska: Omaha.

Wyoming: near Laramie City.

Kansas: Leavenworth; Manhattan; Republican River, N. W. of Fort Riley; Ellis.

Missouri: St. Louis; Osage River; Irondale.

Illinois: Quincy; Lawn Ridge; Decatur; Normal; Pekin; Cairo; Geneva; Stillman's Creek, Marion.

Indiana: Michigan City; Long Lake, Kendallville; Elkhart River, Rome City.

? Tennessee: near Lebanon.

Arkansas: White River, Eureka Springs.

? Alabama: near Bridgeport, Jackson Co. (See page 97.)

Texas.

? New York: Lake George.

47. **C. rusticus.**
Pennsylvania: Pittsburg; Philadelphia Co.?
Ohio: Kelley's Island, Lake Erie; Miami River, Dayton; Yellow Springs; Ohio River, Cincinnati.
Indiana: Ohio River, Madison; White River; Indianapolis.
Illinois: Quincy; Normal.
Kentucky: Kentucky River, Little Hickman; Perryville, Boyle Co.; Salt River.
Tennessee: Cumberland Gap; Lebanon.
Lake Superior.
Wisconsin: Racine; Beloit; Ironton; Fox River.
Iowa: Lizard Creek, Fort Dodge.
Missouri: Osage River.
Arkansas: White River, Eureka Springs.
Texas.

48. **C. spinosus.**
South Carolina: Saluda River.
Georgia: Etowah, Oostenaula, and Coosa Rivers, in the neighborhood of Rome.
Tennessee: Tennessee River, near border of Georgia.
Alabama: Cypress Creek, Lauderdale Co. (See page 117.)

49. **C. Putnami.**
Kentucky: Grayson Springs, Grayson Co.; Green River, near Mammoth Cave.
Tennessee: Cumberland Gap; Knoxville?
? Indiana: Bradford.

50. **C. forceps.**
Alabama: Cypress Creek, Lauderdale Co.
? Tennessee: Knoxville.

Group V.

51. **C. Montezumæ.**
Mexico: neighborhood of City of Mexico; Lake Tezcoco; Puebla; Lake San Roque; Trapuato; Parras, Cohahuila (see page 123); Mazatlan (Pacific Coast).

52. **C. Shufeldtii.**
Louisiana: near New Orleans.

Genus ASTACUS.

1. **A. (Cambaroides) Japonicus.**
Japan: Hakodadi, Yesso.

2. **A. (Cambaroides) Dauricus.**
Siberia: upper portion of the basin of the Amoor River, as far down as Albasin, including the rivers Ingoda, Argoon, Onon, Shilka, and Nercha.

3. **A. (Cambaroides) Schrenckii.**
Siberia: lower portion of the basin of the Amoor River.

4. **A. Klamathensis.**
Dominion of Canada: streams east of the Cascade Mountains, Province of British Columbia.

Washington Territory: upper part of Columbia River and its tributaries at Fort Walla Walla, Wenas Valley, and Spokane Falls.
Oregon: Klamath Lake; Sikan Creek; Des Chutes River.

5. **A. leniusculus.**
Oregon: lower part of the Columbia River.
Washington Territory: lower part of the Columbia River; Puget Sound.

6. **A. Trowbridgii.**
Oregon: Columbia River, near Astoria.
Washington Territory: lower part of the Columbia River; streams running into Shoalwater Bay.

7. **A. nigrescens.**
California: San Francisco.
Washington Territory: Fort Steilacoom. (See page 135.)
Alaska Territory: Oonalaska.

8. **A. Gambelii.**
Utah: Ogden River, Ogden.
Idaho: Fort Hall; west side of Teton Basin.
Montana: mouth of Yellowstone River.
? Wyoming: Willow Creek. (See page 137.)
? California: Santa Barbara. (See page 137.)

9. **A. torrentium.**
Bohemia, Bavaria, Würtemberg, Alsace.

10. **A. pallipes.**
Greece, Austria, Italy, France, Switzerland, Alsace, Spain, England, Ireland. (See page 144.)

11. **A. fluviatilis.**
Russia (Baltic water-shed and small streams of the upper part of the basin of the Dnieper), Austria, Germany, France, Italy? Denmark (Huxley). Artificially introduced into Sweden, whence it has spread into Southeastern Norway. (See page 148.)

12. **A. leptodactylus.**
Russia (in rivers of the Ponto-Caspian basin, and in rivers and lakes emptying into the Baltic and White Seas), Caspian Sea, Hungary (Danube River basin). Artificially introduced into affluents of Tobol River, Siberia, whence it has spread into the Irtish and Obi.*

VAR. **angulosa.**
Crimea and adjacent region, Russia.

13. **A. pachypus.**
Russia: estuaries of rivers flowing into the Black and Caspian Seas; Malaya Oozen River; Caspian Sea.

14. **A. Colchicus.**
Russia: upper portion of Rion River and tributaries, Transcaucasia. Artificially introduced into some of the tributaries of the upper Koor (ancient Cyrus).

* For the Astacus found in Turkestan, see p. 152.

Table showing our present Knowledge of the Distribution of the North American Species of Cambarus and Astacus, arranged according to States and Territories.

1. MAINE. — One species: *C. Bartonii*, in the St. John, Penobscot, and Kennebec River systems. For detailed localities, see p. 62.
2. NEW HAMPSHIRE. — None.
3. VERMONT. — One species: *C. Bartonii*, in affluents of Lake Champlain, at Burlington, Colchester, and Shelburne, Chittenden Co.
4. MASSACHUSETTS. — One species: *C. Bartonii*, at Williamstown, Berkshire Co., and Grafton, Worcester Co.
5. RHODE ISLAND. — None. According to Prof. E. P. Larkin, Cambari (*C. Bartonii* ?) were common forty years ago at Westerly, in the southwestern part of the State, near the Connecticut line.
6. CONNECTICUT. — None. Prof. S. I. Smith tells me that thirty or forty specimens of *C. Bartonii* were introduced into a brook in New Haven in 1880, but none have been seen there since.
7. NEW YORK. — Five species: *C. Blandingii*, *Bartonii* (including var. *robusta*), *immunis*, *affinis*, and *propinquus* (including var. *obscura*). Perhaps also *C. virilis*.
   C. Blandingii probably comes from the southeastern part of the State.
   C. Bartonii is distributed over the whole of the State.
   C. Bartonii, var. *robusta*, is found in the St. Lawrence River basin in Chautauqua, Monroe, Wayne, St. Lawrence, Hamilton, Herkimer, and Jefferson Counties.
   The particular locality for *C. immunis* is unknown.
   C. affinis comes from Niagara, in the western part of the State, and probably lives also in the southeastern part.
   C. propinquus lives in the waters of the St. Lawrence basin, specimens having been received from Grass River, Black Lake, and Canton, in St. Lawrence Co.; Lake Ontario; Garrison Creek, Sackett's Harbor; Oswego; Oneida Lake; Cayuga Lake, Rochester; Niagara; and Forestville, Chautauqua Co.
   C. propinquus, var. *obscura*, is found in Genesee River, at Rochester.
   C. virilis, Lake George ? (See page 98.)
8. NEW JERSEY. — Four species: *C. Blandingii*, *Bartonii*, *Diogenes*, and *affinis*.
   C. Blandingii is recorded from Essex Co. and from the Delaware River and tributaries in Mercer Co.
   C. Bartonii, from Essex, Morris, and Mercer Counties.
   C. Diogenes, from the Delaware meadows near Trenton, Mercer Co.
   C. affinis, from Morris, Monmouth, Mercer, and Camden Counties.
9. PENNSYLVANIA. — Four species: *C. Bartonii*, *Diogenes*, *affinis*, and *rusticus*. *C. Blandingii*, found on the New Jersey side of the Delaware River, doubtless inhabits the eastern part of the State.
   C. Bartonii is found in Bedford, Bradford, Dauphin, Cumberland, Columbia, Lancaster, Philadelphia, Chester, McKean, and Clarion Counties (Delaware, Susquehanna, and Ohio River systems).
   C. Diogenes, at Derry Station, Westmoreland Co. (Ohio River system).

C. affinis, at Bristol, Philadelphia, Brandywine Creek, Reading, Schuylkill, Bainbridge, and Carlisle (Delaware and Susquehanna River systems).

C. rusticus has been found at Pittsburg, in the western part of the State (Ohio River).

10. Delaware. — None. An exploration of this State will probably discover *C. Blandingii, Bartonii, Diogenes, Uhleri*, and *affinis* within its limits.

11. Maryland. — Five species: *C. Blandingii, Bartonii* (including var. *robusta*), *Diogenes, Uhleri*, and *affinis*.

Through the investigations of Mr. P. R. Uhler, of Baltimore, the distribution of Cambari in Maryland is well ascertained.

C. Blandingii is found in the counties on Chesapeake Bay and to the eastward, viz. Baltimore, Caroline, Dorchester, St. Mary's, Somerset, Wicomico, and Worcester.

C. Bartonii inhabits the higher regions in the following counties: Harford, Howard, Montgomery, Frederick, Washington, Garrett, and Alleghany.

C. Bartonii, var. *robusta*, has been collected in Montgomery Co.

C. Diogenes inhabits Baltimore, St. Mary's, Caroline, Dorchester, Worcester, and Garrett Counties.

C. Uhleri has been found in Caroline, Dorchester, Talbot, St. Mary's, Somerset, Wicomico, and Worcester Counties.

C. affinis, Cecil, Harford, Baltimore, Anne Arundel, Montgomery, Charles, Washington, and Alleghany Counties.

12. District of Columbia. — Three species: *C. Bartonii, Diogenes*, and *affinis*.

13. Virginia. — Seven species: *C. Blandingii, Bartonii* (including var. *robusta*), *Diogenes, dubius, affinis, rusticus*, and *Putnami*. *C. Uhleri* will probably be found in Accomack Co.

C. Blandingii has been collected in James River and at Lunenburg.

C. Bartonii appears to be widely distributed in Virginia; the known localities are Clarke Co.; Alexandria Co.; tributaries of Rappahannock River, Stafford Co.; tributaries of James River, Rockbridge Co.; Lunenburg; Franklin, Southampton Co.; Bath Co.; Reed Creek, Wythe Co.; and Holston River, Smyth Co.

C. Bartonii, var. *robusta*, in stony streams running into the Rappahannock and in springs at Fredericksburg, Spottsylvania Co. According to Mr. Uhler, *C. Bartonii*, var. *robusta*, is not found in the tributaries of the Rappahannock in Stafford Co., whence comes the typical *C. Bartonii*.

C. Diogenes, Accomack Co.; Northampton Co.; Fredericksburg, Spottsylvania Co.; Petersburg, Dinwiddie Co.; Alexandria Co.

C. dubius, at one locality, Pennington's Gap, Lee Co., in the southwestern corner of the State.

C. affinis is found in the Potomac River, Fairfax Co.

C. rusticus and *C. Putnami* are found at Cumberland Gap, at the southwestern extremity of the State.

14. West Virginia. — Two species: *C. Bartonii* and *C. dubius*. The former is found in affluents of the Potomac, Grant Co.; Petroleum, Ritchie Co.; White Sulphur Springs, Greenbrier Co.; and in branch of Clinch River, in the southwestern part of the State. The latter (*C. dubius*) comes from Cranberry Summit, Preston Co., in the northern part of the State.

15. North Carolina. — Three species: *C. Blandingii, Bartonii,* and *Diogenes.*

C. Blandingii, from Tarboro; tributaries of Neuse River, at Goldsboro; Kinston; Beaufort; Salmon Creek; and Wilmington. All of these localities are in the eastern part of the State.

C. Bartonii has been found at Kinston, in the eastern part of the State, and in Newman's Fork, in the Blue Ridge Mountains, McDowell Co., in the western part.

C. Diogenes is recorded from Wilmington and Kinston.

16. South Carolina. — Six species: *C. Blandingii* (including var. *acuta*), *troglodytes, Carolinus, acuminatus, latimanus,* and *spinosus.* Perhaps also *C. penicillatus* and *Bartonii.* (See pages 37, 61.)

C. Blandingii comes from Camden, the Saluda River, and Columbia, in the middle region of the State. *C. Blandingii,* var. *acuta,* from Charleston and Beaufort on the sea-coast.

C. troglodytes has been received from Charleston, Oakley, and Columbia.

C. Carolinus, hab. Charleston; Greenville ? (See page 56.)

C. acuminatus, hab. Saluda River.

C. latimanus, hab. Columbia and Greenville.

C. spinosus, hab. Saluda River.

17. Georgia. — Thirteen species: *C. Blandingii, troglodytes, maniculatus, Lecontei, angustatus, pubescens, spiculifer, penicillatus, advena, latimanus, extraneus, Jordani,* and *spinosus.* Perhaps also *C. Bartonii.* (See page 61.)

C. Blandingii and *C. pubescens* come from Richmond Co.

C. troglodytes also comes from Richmond Co. It differs from the typical form of this species. (See page 28.)

C. maniculatus is assigned by Le Conte to the lower part of the State, in ditches.

C. Lecontei has been found at Athens, in the northern part of the State.

C. angustatus comes from the lower regions of the State.

C. spiculifer inhabits the upper part of the State, at Athens; Milledgeville; Atlanta; Roswell, Cobb Co.; Chattahoochee River, Gainesville; Etowah River.

Exact localities for *C. penicillatus* are wanting.

C. advena inhabits Lower Georgia.

C. latimanus is reported from Athens, Milledgeville, and Roswell.

C. extraneus, Jordani, and *spinosus* come from the neighborhood of Rome, in the northwestern part of the State (Etowah, Oostenaula, and Coosa Rivers).

18. Florida. — Four species: *C. fallax, Clarkii, versutus,* and *Alleni.* A species belonging to the *C. Bartonii* group also inhabits Florida.

C. fallax has been collected at the following places: St. John's River at Jacksonville, Orange Bluff, Hawkinsville, Horse Landing, Blue Spring, and Lake Jessup; Magnolia; Indian River; and Titusville, Brevard Co.

C. Clarkii, at Pensacola; and below Horse Landing, on the St. John's River.

C. versutus, at Cape Barrancas (near Pensacola ?).

C. Alleni was discovered at Hawkinsville, on the St. John's River.

19. Alabama. — Eleven species: *C. Blandingii,* var. *acuta, C. Clarkii, Lecontei, versutus, latimanus, Girardianus, immunis, Alabamensis, compressus, spinosus,* and *forceps. C. extraneus* and *C. Jordani* will probably be discovered in the northeastern part of the State, when that territory shall be explored. *C. virilis* is credited to this State with some doubt. (See page 97.)

C. Blandingii, var. *acuta*, at Mobile, in the south, and at Blount Spring, Cullman, Decatur, and Bridgeport, in the north. Decatur and Bridgeport are on the Tennessee River.

C. Clarkii, Lecontei, and *versutus* live in the neighborhood of Mobile.

C. latimanus comes from the northern part of the State, from Blount Spring, Cullman, and Bridgeport.

C. Girardianus, Alabamensis, compressus, spinosus, and *forceps* are found in Lauderdale Co., near the Tennessee River, in the northwestern corner of the State.

C. immunis has been collected at Huntsville, Madison Co., in the northern portion of the State.

The larger part of Alabama remains still unexplored.

20. Mississippi. — Seven species : *C. Blandingii*, var. *acuta, C. Hayi, Clarkii, latimanus, Diogenes, Mississippiensis*, and *lancifer*. Perhaps *C. penicillatus* (see page 37). All the species mentioned above as inhabiting Lauderdale Co., Ala., may be looked for in the northeastern part of Mississippi.

C. Blandingii, var. *acuta*, has been found in a tributary of the Tombigbee River, in Kemper Co., on the eastern border of the State, and near Vicksburg, on the Mississippi River, on the western border.

C. Hayi, from Macon and Artesia, in the western portion of the State.

C. Clarkii and *C. latimanus*, from Ocean Springs, Jackson Co.

C. Diogenes, from Monticello, Lawrence Co.

C. Mississippiensis. Macon.

C. lancifer. The only specimen known up to the present time came from Root Pond, Miss., an unknown locality.

21. Louisiana. — Four species : *C. Blandingii*, var. *acuta, C. Clarkii, Diogenes*, and *Shufeldtii*.

C. Blandingii, var. *acuta*, has been detected in the neighborhood of New Orleans, Tickfaw, and Amite City.

C. Clarkii, around New Orleans and in the Tangipahoa River.

C. Diogenes and ♂. *Shufeldtii* come from the neighborhood of New Orleans.

Only a small tract in the southeastern part of this State has been explored.

22. Texas. — Four species : *C. Clarkii, simulans, virilis*, and *rusticus*.

C. Clarkii. Waller Co. ; San Antonio ; between San Antonio and El Paso del Norte.

C. simulans. Dallas ; " pools east of Canadian River."

The localities of the Texan specimens of *C. virilis* and *C. rusticus* are unknown.

23. Ohio. — Four species : *C. Bartonii, C. Diogenes, C. propinquus*, var. *Sanbornii*, and *C. rusticus*.

C. Bartonii at Marietta, Cincinnati, Yellow Springs, and Columbus (all in the Ohio River basin).

C. Diogenes. Kelley's Island, Lake Erie.

C. propinquus, var. *Sanbornii*, at Oberlin, in the northern part of the State.

C. rusticus. Kelley's Island, Lake Erie; Miami River, Dayton ; Yellow Springs ; Ohio River, Cincinnati.

24. Indiana. — Ten species : *C. Blandingii*, var. *acuta, C. pellucidus, Bartonii, Diogenes, argillicola, immunis, Sloanii, propinquus, virilis*, and *rusticus*. Perhaps also *C. Putnami* in the southern part of the State.

C. Blandingii, var. *acuta*, has been received from Wheatland, Knox Co., in the southeastern part of the State.

C. pellucidus inhabits Wyandotte Cave, Crawford Co., and caves in Harrison Co. Both of these counties are on the southern border of the State.

C. Bartonii has been collected at New Albany, on the Ohio River, and at Indianapolis.

C. Diogenes is recorded from Long Lake, Kendallville, Noble Co.; Mechanicsburg, Henry Co.; and Knox Co.

C. argillicola is found at New Albany.

C. immunis comes from White River; Fall Creek, Indianapolis; and Long Lake, Kendallville.

C. Sloanii. New Albany.

C. propinquus seems to be a common and widely distributed species. Known localities: Elkhart River, Rome City, Noble Co.; Delphi; Indianapolis; White River; Switz City; Michigan City; Turman Creek, Sullivan Co.; Clear Creek, Bloomington.

C. virilis. Michigan City; Long Lake, Kendallville; Elkhart River, Rome City. All of these places are in the northern part of the State.

C. rusticus. Ohio River, Madison; White River; Indianapolis.

25. Illinois. — Eight species: *C. Blandingii*, var. *acuta*, *C. gracilis*, *C. Bartonii*, var. *robusta*, *C. Diogenes*, *C. immunis*, *C. propinquus*, *C. virilis*, and *C. rusticus*.

C. Blandingii, var. *acuta*. This is a very common species in Illinois. It is recorded from Athens, Decatur, Pekin, Normal, Oquawka, Peoria, Lawn Ridge, and Evanston.

C. gracilis. Normal, Lawn Ridge, Athens. "Very common along watercourses in early spring." Forbes.

C. Bartonii, var. *robusta*. One locality in the State, viz. Decatur.

C. Diogenes. Lawn Ridge, Evanston, Belleville, Decatur, Chicago, and Abingdon. Very common.

C. immunis. Aux Plains [?], Belleville, Lawn Ridge, Normal, and Oquawka. "The commonest species of Central Illinois. It is especially frequent in the muddy ponds of the prairies." Forbes.

C. propinquus. Freeport; Ogle Co.; Geneva; Pekin; Normal; Decatur; Aux Plains River.

C. virilis. Quincy; Lawn Ridge; Decatur; Normal; Pekin; Cairo; Geneva; Stillman's Creek, Marion.

C. rusticus. Quincy (*C. placidus* Hagen); Normal.

C. troglodytes has been cited by Hagen as an Illinois species on the authority of a single specimen in the Museum of Comparative Zoölogy (No. 197) marked "Lawn Ridge, Ill., O. Ordway." I am inclined to think the label erroneous.

26. Kentucky. — Nine species: *C. pellucidus*, *C. Bartonii*, *C. Diogenes*? *C. dubius*, *C. cornutus*, *C. Sloanii*, *C. propinquus*, var. *Sanbornii*, *C. rusticus*, and *C. Putnami*.

C. pellucidus. Mammoth Cave and other caves in Edmonson Co.

C. Bartonii. Cumberland Gap, Josh Bell Co.; Smoky Creek, Carter Co.; Kentucky River, Little Hickman, Jessamine Co.; Bear Creek, Grayson's Springs, Grayson Co.; Mammoth Cave, Edmonson Co.

C. dubius. Cumberland Gap.

C. cornutus. Green River near Mammoth Cave.

C. Sloanii. Neighborhood of Louisville?

C. propinquus, var. *Sanbornii.* Smoky Creek, Carter Co.

C. rusticus. Kentucky River, Little Hickman; Perryville, Boyle Co.; Salt River; Cumberland Gap.

C. Putnami. Grayson Springs; Green River, near Mammoth Cave; Cumberland Gap.

27. TENNESSEE. — Twelve species: *C. Blandingii*, var. *acuta*, *C. Bartonii*, *C. latimanus*, *C. dubius*, *C. extraneus*, *C. hamulatus*, *C. immunis*, var. *spinirostris*, *C. Palmeri*, *C. rusticus*, *C. spinosus*, *C. Putnami*, and *C. forceps*? Probably also *C. virilis* and *C. Diogenes*. (See pages 72, 98.)

C. Blandingii, var. *acuta.* Memphis.

C. Bartonii. Cumberland Gap; Doe River, Carter Co.; Lineville Cave, near Blountsville, Sullivan Co.; Knoxville.

C. latimanus. Ashland City, Cheatham Co. (Cumberland River). (See page 69.)

C. dubius. Cumberland Gap.

C. extraneus. Tennessee River, near the border of Georgia.

C. hamulatus. Nickajack Cave, in the southern part of the State.

C. immunis, var. *spinirostris.* Obion Co., in the northwestern corner of the State.

C. Palmeri. Obion Co.

C. rusticus. Cumberland Gap; Lebanon.

C. spinosus. Tennessee River, near the border of Georgia.

C. Putnami. Cumberland Gap; Knoxville?

C. forceps? Knoxville. (See page 119.)

28. MICHIGAN. — Four species: *C. Diogenes*, *argillicola*, *immunis*, and *propinquus.* Also *C. Bartonii* and *C. rusticus* in Lake Superior.

C. Diogenes and *C. immunis* have been found at Detroit.

C. argillicola, at Detroit and East Saginaw.

C. propinquus, in St. Clair River and Detroit River; at Northville; Ann Arbor; Ecorse; and Otsego (Kalamazoo River).

29. WISCONSIN. — Seven species: *C. Blandingii*, var. *acuta*, *C. gracilis*, *Diogenes*, *immunis*, *propinquus*, *virilis*, and *rusticus.*

C. Blandingii, var. *acuta*, is recorded from Racine, on Lake Michigan, and from Sauk City, on the Wisconsin River.

C. gracilis. Racine.

C. Diogenes. Tributaries of Pecatonica River, Green Co.; Appleton; Racine.

C. immunis. Milwaukee.

C. propinquus. Tributaries of Pecatonica River, Green Co.; Madison.

C. virilis. This appears to be common. It has been received from Appleton; Baraboo River, Ironton; Sauk City; Wisconsin River; Sugar River; Rock River; Jefferson; and Milwaukee.

C. rusticus. Racine; Beloit; Ironton; Fox River.

30. MINNESOTA. — Two species: *C. immunis* and *C. virilis*, the former from Richfield, Hennepin Co., the latter from Lake Superior, Mississippi River, and lakes and streams in Hennepin Co.

31. IOWA. — Seven species: *C. Blandingii*, var. *acuta*, *C. gracilis*, *Diogenes*, *immunis*, *propinquus*, *virilis*, and *rusticus.*

C. Blandingii, var. *acuta.* West Liberty, Dubuque.

C. gracilis and *C. Diogenes.* Davenport.

C. propinquus. Davenport; Ottumwa.

C. immunis. West Liberty.

C. virilis. Davenport; Burlington; Fort Dodge; Spring Vale; Des Moines River; Bedford.

C. rusticus. Lizard Creek, Fort Dodge.

The State has been little explored. All of the above-named localities are on the eastern border of the State, except Fort Dodge and Spring Vale, which are in the central part.

32. Missouri. — Seven species: *C. Blandingii*, var. *acuta*, *C. Diogenes*, *medius*, *immunis*, *Harrisonii*, *virilis*, and *rusticus*. Possibly *C. Bartonii* in the Osage River. (See page 61.)

C. Blandingii, var. *acuta*, occurs at St. Louis.

C. Diogenes. Carroll Co. and St. Louis.

C. medius. Irondale, Washington Co.

C. immunis. St. Louis.

C. Harrisonii. Irondale, Washington Co.

C. virilis. St. Louis; Osage River; Irondale.

C. rusticus. Osage River.

33. Arkansas. — Four species: *C. Diogenes*, *virilis*, *rusticus*, and one undetermined species belonging to the *C. Blandingii* group.

C. Diogenes. Locality unknown.

C. virilis. White River, Eureka Springs.

C. rusticus. White River, Eureka Springs.

Sp. indet. Salina River, Arkadelphia.

34. Indian Territory. — None.

35. Kansas. — Four species: *C. simulans*, *Diogenes*, *immunis*, and *virilis*.

C. simulans. Fort Hays.

C. Diogenes. Leavenworth.

C. immunis. Leavenworth; Ellis.

C. virilis. Leavenworth; Manhattan; Republican River northwest of Fort Riley; Ellis.

36. Nebraska. — One species, *C. virilis*, from Omaha, on the eastern border of the State.

37. Dakota Territory. — Three species: *Cambarus Nebrascensis*, *C. virilis*, and *Astacus Gambelii*.

C. Nebrascensis from Fort Pierre, at the confluence of the Bad and Missouri Rivers (Girard).

C. virilis from the Red River of the North, near Pembina, and from the Souris or Mouse River.

A. Gambelii from the mouth of the Yellowstone River, on the boundary between the Territories of Dakota and Montana (the easternmost locality for the genus Astacus).

38. Montana Territory. — One species, *Astacus Gambelii*, from the mouth of the Yellowstone River.

39. Wyoming Territory. — Three species: *C. Diogenes*, *immunis*, and *virilis*. Perhaps also *Astacus Gambelii*. (See page 137.)

C. Diogenes has been found at Cheyenne.

C. immunis and *C. virilis* at Laramie City.

40. Colorado. — One species, *C. Diogenes*, from Clear Lake. I do not know in what part of the State this is.

41. New Mexico Territory. — None.

42. Arizona Territory. — None.

43. Utah Territory. — One species, *Astacus Gambelii*, from Ogden River, Ogden.

44. Nevada. — None.

45. Idaho Territory. — One species, *A. Gambelii*, from Fort Hall on the Snake River, and from the west side of Teton Basin.

46. Washington Territory. — Four species: *A. Klamathensis*, *A. leniusculus*, *A. Trowbridgii*, and *A. nigrescens*.

A. Klamathensis from the section east of the Cascade Range, at Fort Walla Walla, Wenas Valley, and Spokane Falls (upper part of the Columbia River and tributaries).

A. leniusculus from the lower part of the Columbia River and Puget Sound.

A Trowbridgii. Lower part of Columbia River, near Astoria; streams running into Shoalwater Bay.

A. nigrescens. Fort Steilacoom on Puget Sound. (See page 135.)

47. Oregon. — Three species: *A. Klamathensis*, *A. leniusculus*, and *A. Trowbridgii*.

A. Klamathensis. Klamath Lake; Sikan Creek; and Des Chutes River.

A. leniusculus. Lower part of the Columbia River.

A. Trowbridgii. Columbia River near Astoria.

48. California.* — Two species: *A. Klamathensis* and *A. nigrescens.* Perhaps also *A. Gambelii.* (See page 137.)

A. Klamathensis in Klamath Lake on the northern border of the State.

A. nigrescens from the neighborhood of San Francisco.

49. Alaska Territory. — One species, *A. nigrescens*, from Oonalaska Island.

50. Dominion of Canada. — Four species: *Cambarus Bartonii* (including var. *robusta*), *C. argillicola*, *C. propinquus*, and *Astacus Klamathensis.* *C. Diogenes*, which occurs at Detroit, Mich., will doubtless be found on the Canadian side of the river.

C. Bartonii. St. John, Prov. New Brunswick; Montreal, Prov. Quebec?

C. Bartonii, var. *robusta.* Toronto and Weston, Prov. Ontario.

C. argillicola. Toronto, Prov. Ontario.

C. propinquus. Montreal, Prov. Quebec; Toronto, Prov. Ontario.

A. Klamathensis. Streams east of Cascade Mountains, Prov. British Columbia.

51. Mexico. — Four† species: *C. Wiegmanni*, *Mexicanus*, *immunis*, and *Montezumæ*. But little is known concerning the distribution of these species in Mexico. The only specimen of *C. Mexicanus* which I have seen came from Mirador. The locality given by Saussure for *C. Aztecus* (= *C. Mexicanus*?) is "Tomatlan, dans les Terres-Chaudes." Von Martens records the same species from Puebla. *C. immunis* has been found at Orizaba, *C. Montezumæ* in the neighborhood of the city of Mexico, at Puebla, Parras in the State of Cohahuila, and at Mazatlan on the Pacific coast. A mutilated specimen, probably *C. Wiegmanni*, in the U. S. National Museum, comes from the Isthmus of Tehuantepec.

* In the U. S. National Museum there is a small specimen of *Cambarus obscurus* labelled "California" (No. 2331). The locality is probably erroneous.

† *Five* species, if *C. Aztecus* Saussure be distinct from *C. Mexicanus* Erichson. (See page 51.) An undescribed species belonging to the Parastacinæ was collected by John Xantus at Colima, on the west coast. This is the only Parastacine yet discovered north of the equator.

52. Guatemala. — A species of Cambarus was obtained by Mr. Salvin near Coban, in the Province of Alta Vera Paz, at an elevation of about 4,300 feet above the sea. (See Huxley, Proc. Zoölog. Soc. London, 1878, p. 763; The Crayfish, p. 312, fig. 78; also page 7 of this work.) This is the most southern locality from which the genus Cambarus has been obtained.

53. Cuba. — One species, *C. Cubensis*. The examples in the Museum of Comparative Zoölogy were obtained near Havana. According to Von Martens there are indications of a second species of Cambarus native to Cuba. (See page 53.)

Distribution of the North American Species of Cambarus and Astacus according to the River Systems.

Viewing the distribution of the various species according to the river systems, it appears that the St. John, Penobscot, and Kennebec Rivers are inhabited by only a single species, *C. Bartonii*. In the remaining large rivers of New England, the Androscoggin, the Saco, the Merrimac, and the Connecticut, crayfishes are unknown. *C. Bartonii* has been found in springs at Grafton, Mass., in the Blackstone River basin.

In the Hudson River basin *C. Bartonii* is widely distributed. Near the mouth of this river, in Essex Co., New Jersey, *C. Blandingii* occurs. This is probably its northern limit in the east.

From the Delaware and its tributaries come *C. Blandingii*, *Bartonii*, *Diogenes*, and *affinis*.

In the area drained by the rivers that empty into Chesapeake Bay, the chief of which are the Susquehanna, Potomac, Rappahannock, and James, are found *C. Blandingii*, *C. Bartonii*, *C. Bartonii*, var. *robusta*, *C. Diogenes*, *Uhleri*, and *affinis*. *C. Uhleri* is known only in the low region on the Chesapeake and Atlantic coasts of Maryland, often in brackish and salt water.

The rivers of North Carolina (Roanoke, Tar, Neuse, Cape Fear, and tributary streams) are inhabited by *C. Blandingii*, *Bartonii*, and *Diogenes*.

The Santee River and the minor streams of South Carolina yield *C. Blandingii*, *C. Blandingii*, var. *acuta*, *C. troglodytes*, *Carolinus*, *acuminatus*, *latimanus*, *spinosus*, and *Bartonii*, the last species in the head-waters of the Santee among the mountains of Western North Carolina.

The rivers which flow into the Atlantic Ocean in the State of Georgia (Savannah, Altamaha, etc.) furnish *C. Blandingii*, *pubescens*, *troglodytes*, *Lecontei*, *spiculifer*, *penicillatus*, and *latimanus*. In the lower part of the State are also found *C. advena*, *angustatus*, and *maniculatus*.

In the St. John's River, Florida, have been found *C. fallax*, *Clarkii*, and *Alleni*. *C. fallax* and *C. Alleni* have not been found outside of the State of Florida.

In the upper portion of the Chattahoochee River live *C. spiculifer* and *C. latimanus*.

In the upper part of the course of the Alabama River (Etowah, Oostenaula, and Coosa Rivers), *C. extraneus*, *Jordani*, and *spinosus* have been secured; in the upper part of the Tombigbee, *C. Blandingii*, var. *acuta*, *C. latimanus*, *Hayi*, and *Mississippiensis*. At Mobile, where the Alabama and Tombigbee, after uniting, empty into Mobile Bay, *C. Blandingii*, var. *acuta*, *C. Clarkii*, *Lecontei*, and *versutus* occur.

Mississippi River System. — From the portion of the Mississippi Valley south of the

Ohio and its affluents are recorded *C. Blandingii*, var. *acuta*, *C. Clarkii* (near the mouth of the river, at New Orleans, etc.), *C. Diogenes*, *C. immunis*, var. *spinirostris*, and *C. Palmeri* (Obion Co., Tennessee), *C. virilis* and *C. rusticus* (from White River, Arkansas), and *C. Shufeldtii* (New Orleans).

In the region drained by the Tennessee River are found, (*a.*) in the upper part of its course, *C. Bartonii*, *dubius* (Cumberland Gap), *rusticus* (Cumberland Gap), *Putnami*, *extraneus*, *hamulatus*, and *spinosus* (the last three from near the border of the State of Georgia). (*b.*) In the southern bend of the river, within the State of Alabama, *C. Blandingii*, var. *acuta* (Bridgeport and Decatur), *C. latimanus* (Bridgeport), *immunis* (Huntsville), *Girardianus*, *Alabamensis*, *compressus*, *spinosus*, and *forceps* (the last five species from Lauderdale Co. in the northwestern corner of Alabama).

In the Ohio River and its tributaries (excepting the Tennessee) are found *C. Blandingii*, var. *acuta*, *C. pellucidus*, *Bartonii*, *Diogenes*, *argillicola*, *dubius* (Preston Co., W. Va., Cumberland Gap, Ky.), *cornutus*, *immunis*, *virilis* (Cairo, Ill.), *rusticus*, *Putnami*, *Sloanii*, *propinquus*, and *C. propinquus*, var. *Sanbornii*.

In the Mississippi Valley to the north of the Ohio are found *C. Blandingii*, var. *acuta*, *C. gracilis*, *C. Diogenes*, *C. Bartonii*, var. *robusta* (Decatur, Ill.), *C. medius* (Irondale, Mo.), *C. Harrisonii* (Irondale, Mo.), *C. immunis*, *virilis*, *rusticus*, and *propinquus*.

From the Missouri and its affluents come *C. simulans* (Fort Hays, Kan.), *C. Nebrascensis* (Fort Pierre, Dakota), *C. Diogenes* (Colorado, Wyoming, Kansas), *C. immunis* (Laramie City, Wyo., Leavenworth, Kan.), *C. virilis* (Laramie City, Wyo., Nebraska, Iowa, Kansas), and *Astacus Gambelii* (at the confluence of the Yellowstone and the Missouri, and perhaps also in the Platte River drainage in Wyoming).

But little is known concerning the distribution of crayfishes in the rivers that flow into the Gulf of Mexico west of the Mississippi. *C. Clarkii*, *simulans*, *virilis*, and *rusticus* have been collected in Texas; *C. Wiegmanni*, *Mexicanus*, *Aztecus* (= *C. Mexicanus* ?), *immunis*, and *Montezumæ*, in Mexico.

The island of Cuba affords a peculiar species, *C. Cubensis*.

In the great basin of the St. Lawrence River are found *C. Blandingii*, var. *acuta*, *C. Bartonii*, *C. Bartonii*, var. *robusta*, *C. Diogenes*, *C. argillicola*, *C. gracilis*, *C. immunis*, *C. virilis*, *C. rusticus*, *C. propinquus*, *C. propinquus*, var. *Sanbornii*, *C. propinquus*, var. *obscura*, and *C. affinis*. Of these, *C. virilis*, *rusticus*, *propinquus*, and *Bartonii* are found in Lake Superior; *C. Blandingii*, var. *acuta*, *C. gracilis*, *Diogenes*, *immunis*, *virilis*, *rusticus*, and *propinquus*, in Lake Michigan and its affluents; *C. argillicola* and *C. propinquus*, in the Lake Huron drainage; *C. Bartonii*, *C. Bartonii*, var. *robusta*, *C. Diogenes*, *C. argillicola*, *C. immunis*, *C. propinquus*, *C. propinquus*, var. *Sanbornii*, and *C. rusticus*, in Lake Erie and tributary streams; in Lake Ontario and its affluents, *C. Bartonii*, *C. Bartonii*, var. *robusta*, *C. argillicola*, *C. propinquus*, *C. propinquus*, var. *obscura* (Rochester, N. Y.), and *C. affinis* (Niagara). In the St. Lawrence and its affluents from the lower end of Lake Ontario down to Montreal are found *C. Bartonii* and *C. propinquus;* in Lake Champlain and tributary streams, *C. Bartonii*.

In the Hudson's Bay water-shed, *C. virilis* occurs in Lake Winnipeg, Saskatchewan River, and the Red River of the North.

The basin of the Great Salt Lake is inhabited by *Astacus Gambelii*.

The upper waters of the Columbia River furnish *Astacus Gambelii* (head of Snake River, Idaho) and *A. Klamathensis*. These are replaced by *A. leniusculus* and *A. Trowbridgii* in the lower part of the Columbia. *A. Klamathensis* is also found in the upper part of the rivers of British Columbia, and as far south as Klamath Lake on the north-

ern bounds of California. From the neighborhood of San Francisco, California, comes *A. nigrescens*, a species which apparently extends far north along the coast, as there are specimens in the U. S. National Museum said to have been taken at Fort Steilacoom, Washington Territory, and Oonalaska Island, Alaska Territory (lat. 53° 52′ N.).

On the west coast of Mexico, at Mazatlan, a Cambarus occurs, *C. Montezumæ;* also a Parastacine at Colima.

General Conclusions derived from the Facts known concerning the Geographical Distribution of Crayfishes.

I. The crayfishes of the Southern hemisphere (Australia, Tasmania, New Zealand, Feejee Islands, Madagascar, and South America) possess certain characters in common (given on page 2) which separate them as a subfamily, Parastacinæ, from the crayfishes of the Northern hemisphere (Europe, Asia, and North America), which form a second subfamily, Potamobiinæ (page 2). This was first pointed out by Huxley,* who suggests, in explanation of this fact in the distribution of the crayfishes, that their marine ancestors were already differentiated into a Parastacine type in the Southern hemisphere and a Potamobiine type in the Northern hemisphere, when they took possession of the fresh waters. The distribution of the different genera of Parastacinæ in the Southern hemisphere will be considered in the second part of this memoir.

II. The crayfishes belonging to the subfamily Potamobiinæ occupy four geographical areas, viz.: —

(1.) The eastern and central part of the North American continent. This area embraces that portion of North America which lies east of the Rocky Mountains, drained by the rivers that flow into the Atlantic Ocean, Hudson's Bay, and the Gulf of Mexico, from Lake Winnipeg on the north to Guatemala on the south. It includes the island of Cuba.

(2.) The western slope of the North American continent, or the area drained by the rivers that flow into the Pacific Ocean. In this area is included the basin of the Great Salt Lake, which probably drained into the Pacific at a former period.

(3.) A tract on the eastern side of Asia, including the Amoor River basin and Japan.

(4.) An area including the greater part of Europe, and extending into Western Asia so as to embrace the Aralo-Caspian basin.

Thus we have an eastern North American and a western North American area, an eastern Eurasiatic † and a western Eurasiatic area. The two areas in North America are in close juxtaposition at the Rocky Mountain divide, whereas the eastern and western Eurasiatic crayfishes are sundered by a broad tract in Central Asia whose waters are wholly destitute of these animals, as far as known.

III. (1.) The western Eurasiatic and the western North American crayfishes belong to the genus Astacus (page 125). They are closely related, the European species differing from the western North American species barely more than the latter do from each other. (2.) The eastern North American crayfishes (Cambarus, page 3) are generically distinct from the western North American and European species. (3.) The eastern Eurasiatic crayfishes form a natural group (Cambaroides, page 126), in which the characters of Astacus and Cambarus are combined.

* Proc. Zoölog. Soc. London, 1878.

† Eurasia is the single continent artificially divided into Europe and Asia.

In other words, the Astaci of Western North America find their closest kin, not in their next neighbors, the crayfishes on the eastern side of the Rocky Mountains, nor in those of Eastern Asia, but in the Astaci of Europe; the Cambari of Eastern North America are most nearly related, not to the crayfishes on the other side of the Rocky Mountains, nor to those on the opposite shore of the Atlantic, but to those of the remotest district, Eastern Asia. The two areas inhabited by Astacoid forms alternate with two areas of Cambaroid forms.

"If the facts had been the other way," says Huxley,* "and the West American and Amoor-Japanese crayfish had changed places, the case would have been intelligible enough. The primitive Potamobine stock might then have been supposed to have differentiated itself into a western Astacoid and an eastern Cambaroid form; the latter would have ascended the American, and the former the Asiatic rivers. As the matter stands, I do not see that any plausible explanation can be offered without recourse to suppositions respecting a former more direct communication between the mouth of the Amoor and that of the North American rivers, in favor of which no definite evidence can be offered at present."

In order to explain this singular mode of distribution of the Potamobiinæ, let it be supposed that the marine progenitors of the existing crayfishes were differentiated, not only into a northern type with the Potamobiine characters and a southern type with the Parastacine characters, but that the Potamobiine type was already differentiated into an Astacoid form and a Cambaroid form (with some of the essential characters of the modern Cambarus), both of which became widely distributed around the globe in the ocean which lay to the north of the ancient continents. After their adaptation to life in fresh water, both forms would be driven southward by the climatic changes which have occurred within comparatively recent geological periods, into all parts of each continent.† The same causes, whether similar climatic conditions or other, which have operated in the preservation of so many allied forms of plants and animals on the corresponding sides of the Eastern and Western continents, would promote the survival of the descendants of the one type of crayfish in Eastern North America and Eastern Asia, of the other in Western North America and Europe. Unfortunately, we have no palæontological evidence touching the former distribution of Astacus and Cambarus, the few fossils known being too imperfect for the purpose; but the assumption of the former coexistence of Astacus and Cambarus in the same area of distribution receives positive support from the fact that a blind Cambarus still survives in the subterranean seclusion of the caves of Carniola. (See page 42.) It will, moreover, be borne in mind, that in other cases of animals and plants that exemplify the same peculiarities of distribution with the crayfishes, direct palæontological evidence is not wanting to prove the former general distribution of forms now restricted to widely separated localities. To instance a remarkable case among the marine Crustacea, the peculiar genus Limulus is represented on the eastern coast of North America by *L. Polyphemus*. No Limuli exist on the Pacific shores of America nor on the coasts of Europe, but closely related species inhabit the eastern side of Asia (Japan, Cochin China, the Moluccas, etc.). Now, in the lithographic slates of Solenhofen abundant fossil Limuli clearly testify to their former existence in the seas of Europe.

The reader will observe that in this suggestion of a possible explanation of the peculiar relations existing between the crayfishes of Western North America and of Europe on

* The Crayfish, p. 334.

† That the crayfishes had become fresh-water animals in Tertiary times is shown by the fossils of Idaho and Wyoming.

the one hand, and between those of Eastern North America and of Eastern Asia on the other, I have simply made a new application of the theories advanced by Huxley* to explain the differences between the crayfishes on the two sides of the equator, and by Asa Gray† to account for phenomena in the distribution of plants similar to those presented by the crayfishes of the Northern hemisphere.

The absence of Astacidæ over a large part of Asia is well known. None are found in the great rivers that flow into the Arctic Ocean, nor in those of the central and southern portions of the continent. In connection with the absence of crayfishes from the rivers of Southern Asia, Milne Edwards‡ has suggestively observed that these waters are populous with fluviatile crabs of the family Telphusidæ. Indeed, as a general rule, crayfishes are unknown in regions where fluviatile crabs abound, having succumbed, perhaps, to their more highly organized rivals. Huxley remarks, moreover, that if the western Eurasiatic crayfishes are derived from a primitive Aralo-Caspian stock, as seems probable, the great Asiatic highlands would form an obstacle to their southward extension into India, while the severity of the Siberian winter and the recent submergence of the land beneath the ocean are invoked to account for the absence of these animals from the great Asiatic rivers that empty into the Arctic Ocean.

IV. The only islands in the Northern hemisphere known to be inhabited by crayfishes lie near the mainland, and the crayfishes contained therein are either the same species as those of the adjacent part of the continent, or closely related species. Thus, the species found in England and Ireland and in the islands of Cherso and Veglia are the same as those of the western and southern parts of Continental Europe, viz. *Astacus pallipes*. The Japanese crayfishes (*Cambaroides Japonicus*) are nearly related to those of the Amoor River (*Cambaroides Dauricus* and *C. Schrenckii*), the Cuban species (*Cambarus Cubensis*) to those of Mexico (*C. Mexicanus*). The chances in favor of accidental transportation of animals having the habits of crayfishes across bodies of salt water such as separate the islands in question from the continents are so small, that it seems more probable that their distribution was effected through migrations at a former period, when the present insulated areas were continuous with the neighboring continents. The connection of the British Isles with the continent of Europe in post-glacial times is admitted by geologists. Evidence pointing to the former connection of the islands of the West Indian archipelago with each other and with the mainland has been obtained already from the land fauna and flora of these islands.§

V. Blind crayfishes have been found in the caves of Carniola and the United States. The Carniola blind crayfish is not merely specifically, but even generically, distinct from the other species of Europe, and belongs to the same genus as the crayfishes of the Atlantic slope of North America (Cambarus). As the genus Cambarus in North America was not developed under the influences affecting cavern life, it would seem that the generic identity of the Carniola cave species with the North American forms cannot be due to similarity of surroundings, but rather to genetic connection. In other words, it is probable

* *Op. cit.*

† Mem. Amer. Acad. Arts and Sci., New Series, VI. 377–452, 1857.—Proc. Amer. Assoc. Adv. Sci., 21st Meeting, pp. 1–31, 1873.

‡ Histoire Naturelle des Crustacés, III. 584, 1840.

§ Cf. Bland, Proc. Amer. Philosoph. Soc., XII. 56, 1871; Ann. Lyc. Nat. Hist. N. Y., X. 311, 1874; Ann. N. Y. Acad. Sci., II. 117, 1880. Eggers, Bull. U. S. Nat. Mus., No. 13, 1879. The *extinct* fauna of Cuba includes a giant sloth, Megalonyx (Leidy, Proc. Acad. Nat. Sci. Phila., 1868, p. 178); and in the little island of Anguilla, which is only thirty-five square miles in area, are found the fossil remains of several species of gigantic rodents and a deer (Cope, Proc. Amer. Philosoph. Soc., XI. 183, 1869; Ibid., XI. 608, 1870).

that the genus Cambarus once flourished in the rivers of Europe. (See pages 42, 176.) The cave species of the United States belong to the same genus as those inhabiting the outside waters, but are not closely related to any of them. They may be considered as derived from an ancient outside fauna of that region. (See page 42.)

VI. The genus Cambarus ranges from Lake Winnipeg to Cuba and Guatemala, from New Brunswick to Wyoming Territory (in Mexico to the Pacific Ocean). Like the Unionidæ of the same waters, the Cambari are wonderfully rich in species, the evolution of specific forms having gone on much more rapidly here than in the regions inhabited by their relatives, the Astaci. Within the limits of the United States west of the Rocky Mountains, and in Mexico and Cuba, fifty-two species of Cambarus are known, while the described Astaci (including the subgenus Cambaroides) of Europe, Asia, and the Western United States number but fourteen species, the chances of discovery of new species through further exploration being greatly in favor of the genus Cambarus.

With regard to the distribution of the species of Cambarus, the whole territory occupied by them seems to fall into two provinces; — a southern province, embracing the Atlantic States south of North Carolina, the Gulf States, Mexico, and Cuba; and a northern province, which includes the Atlantic States north of South Carolina, the States of the Mississippi Valley (*in sensu extenso*) north of the Gulf States, and Canada. The southern province is characterized by the prevalence of species belonging to Groups I. and II. (*C. Blandingii* and *C. advena* groups). All of the fifteen species of Group I., excepting *C. pellucidus*, are found within the limits of this province as defined above. *C. pellucidus* comes from the caves of Kentucky and Southern Indiana. Five of the six species belonging to Group II. are found in the southern province; the fifth, *C. gracilis*, is a northern species (Wisconsin, Iowa, Illinois). *C. simulans* has been found in Texas and to the northward in Kansas. The only two species belonging to Group V. (*C. Montezumæ* and *C. Shufeldtii*) are confined to the southern province, in Mexico and Louisiana. One species belonging to Group I., *C. Blandingii*, extends northward beyond the limits of the southern province as far as New York along the Atlantic coast, and up to Wisconsin in the Mississippi Valley. In both the East and the West, the northern form distinctly differs from the southern. (See page 22.)

Besides the species of Cambari belonging to Groups I., II., and III., there are found within the limits of the southern province six species* belonging to Group III. (*C. Bartonii* group), and nine species† of Group IV. (*C. affinis* group). Only eight of them, however, are restricted to the southern province; and of these eight, three (*C. Girardianus, Alabamensis*, and *compressus*) are known only from the extreme northwestern corner of Alabama, in the Tennessee River basin, while three (*C. acuminatus, latimanus*, and *Jordani*) chiefly inhabit the upper portions of the river-courses in the mountainous regions of the province. *C. extraneus* and *C. spinosus* are border species with respect to the two provinces, being found in the streams on each side of the Alleghany divide, in South Carolina, Georgia, and Tennessee. *C. Diogenes, immunis, virilis*, and *rusticus* have their populous centres of distribution in the north, although they have extended far southward on certain lines.

In the northern province the species of the third and fourth groups (allies of *C. Bartonii* and *C. affinis*) are the dominant forms, wellnigh to the exclusion of those belonging to the first and second groups. Nine species belonging to Group III. and eleven to

* *C. acuminatus, C. latimanus, C. Diogenes, C. extraneus, C. Girardianus*, and *C. Jordani*.

† *C. immunis, C. Mississippiensis, C. Alabamensis, C. compressus, C. lancifer, C. virilis, C. rusticus, C. spinosus*, and *C. forceps*.

Group IV. are found here, while Groups I. and II. are represented by only two species each, *C. Blandingii* and *pellucidus*, and *C. simulans* and *gracilis*. The southern province contains thirty-six species, twenty-eight of which are not found beyond its limits. From the northern province twenty-four species are known, sixteen of them peculiar to it.

VII. In the territory occupied by the genus Cambarus the waters of the South and West are richer in species than the waters of the Northeast. This will appear evident on inspection of the table of distribution according to States, on page 165, or according to river systems, on page 173. The well-explored New England States afford but one species; Pennsylvania, four or five;—while the less narrowly searched States to the south and west yield much larger numbers; as Alabama, eleven; Georgia, thirteen; Tennessee, twelve; Indiana, ten.

VIII. The crayfishes of the upper part of a river basin are often different from those found in the lower part of its course,* even when the river does not traverse a great distance in latitude. The distinction between the species of the upper waters and those of the lower waters is most marked in rivers that have a heavy fall from their source to their mouth. In the upper waters of the Santee basin, for instance, *C. Bartonii, latimanus, acuminatus*, and *spinosus* are found; in the lower portion of the same basin live *C. Blandingii*, var. *acuta*, and *C. troglodytes*. So with Astacus: the lower part of the Columbia River, near its mouth, is frequented by *A. leniusculus* and *A. Trowbridgii;* while above the Cascades *A. Klamathensis* is found, and yet higher, in the head-waters of the Snake River in Idaho, *A. Gambelii*.

IX. Distribution is often controlled by the character of the stream (temperature, rapidity, purity, etc.) rather than by continuity of water communication. Thus, a species of restricted range may be found in the upper waters of streams that rise in the same mountain range, but flow in opposite directions and discharge at points far distant, and yet be unknown in the lower portions of the same streams. For example, *C. extraneus* and *C. spinosus* are found in the upper waters of the Santee, Alabama, and Tennessee River systems. This fact is more easily explained in the case of crayfishes, many of which possess a singular faculty for living a long time away from the water, than in the case of fresh-water fishes, where the same phenomenon of distribution has been pointed out by Cope and by Jordan.†

* This was observed by Agassiz in the case of fishes and mollusks. See his "Lake Superior," p. 247, Boston, 1850.

† See Cope, Journ. Acad. Nat. Sci. Phila., New Series, VI. 207 *et seqq.*, and Jordan, Bull. U. S. Nat. Mus., No. 12.

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[Synonymes are printed in Italics.]

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" " Sanbornii FAX.	91
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EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. Cambarus Alleni Fax. Male, form I. Hawkinsville, Fla. . . . . × 2
" 2. Cambarus simulans Fax. Male, form I. Dallas, Tex. . . . . × 1
" 3. Cambarus pubescens Fax. Male, form II. McBean Creek, Ga. . . . . × 2
" 4. Cambarus Hayi Fax. Male, form I. Eastern Mississippi. . . . . × 1
" 5. Cambarus immunis, var. spinirostris Fax. Male, form II. Obion Co., Tenn. . . × 2

PLATE II.

Fig. 1. Cambarus Cubensis Erichs. Male, form I. Havana, Cuba. . . . . × 2
" 2. Cambarus Lecontei Hag.* Male, form I. Type. Mobile, Ala. . . . . × 1
" 3. Cambarus latimanus Hag. Female. Athens, Ga. . . . . × 1½
" 4. Cambarus fallax Hag. Male, form I. Type. Florida. . . . . × 2
" 5. Cambarus spiculifer Hag. Male, form I. Athens, Ga. . . . . × 1½
" 6. Cambarus Montezumæ, var. tridens Von Mart.† Female. Mexico. . . . . × 3

PLATE III.

Fig. 1. Cambarus Harrisonii Fax. Male, form I. Irondale, Mo. . . . . × 2
" 2. Cambarus Mississippiensis Fax. Male, form I. Eastern Mississippi. . . . . × 1½
" 3. Cambarus Jordani Fax. Male, form II. Rome, Ga. . . . . × 2
" 4. Cambarus medius Fax. Male, form I. Irondale, Mo. . . . . × 2
" 5. Cambarus acuminatus Fax. Female. Saluda River, S. C. . . . . × 2
" 6. Cambarus Palmeri Fax. Male, form II. Obion Co., Tenn. . . . . × 2

PLATE IV.

Fig. 1. Cambarus Girardianus Fax. Male, form II. Lauderdale Co., Ala. . . . . × 1½
" 2. Cambarus argillicola Fax. Male, form I. Detroit, Mich. . . . . × 2
" 3. Cambarus dubius Fax. Male, form I. Preston Co., W. Va. . . . . × 1½
" 4. Cambarus Alabamensis Fax. Male, form I. Lauderdale Co., Ala. . . . . × 2
" 5. Cambarus Sloanii Bundy. Male, form I. New Albany, Ind. . . . . × 1
" 6. Cambarus hamulatus Fax. Male, form II. Nickajack Cave, Tenn. . . . . × 2

* The rostrum is badly drawn. Compare the description on page 29.
† The acumen of the rostrum is broken off in the specimen here figured.

PLATE V.

Fig. 1. Cambarus cornutus Fax. Male, form I. Green River, Ky. . . . . × 1
" 2. The same. Side view of head.
" 3. Cambarus propinquus, var. Sanbornii Fax. Male, form I. Carter Co., Ky. . . . × 2
" 4. Cambarus forceps Fax. Male, form I. Lauderdale Co., Ala. . . . . × 3
" 5. Cambarus Putnami Fax. Male, form I. Grayson Springs, Ky. . . . . × 2
" 6. Cambarus compressus Fax. Male, form I. Lauderdale Co., Ala. . . . . × 4

PLATE VI.

Fig. 1. Astacus Klamathensis Stimps. Male. Fort Walla Walla, Washington Territory. . × 1
" 2. The same. Male. Sikan Creek, Oregon. . . . . × 1
" 3. Astacus (Cambaroides) Schrenckii Fax. Female. . . . . × 3
" 4. Astacus leniusculus Dana. Male. . . . . × 1

PLATE VII.

Fig. 1. Cambarus Shufeldtii Fax. Female. New Orleans, La. . . . . × 4

Figs. 2–3ᵃ′. *First abdominal appendages of male.*

" 2. Cambarus Blandingii Erichs. Trenton, N. J. Form I., outer side. . . . . × 6
" 2′. The same. Form I., inner side. . . . . × 6
" 2″. The same. Form I., front. . . . . × 6
" 2ᵃ. The same. Form II., front. . . . . × 6
" 2ᵃ′. The same. Form II., inner side. . . . . × 6
" 3. Cambarus Hayi Fax. Form I., outer side. . . . . × 6
" 3′. The same. Form I., inner side. . . . . × 6
" 3ᵃ. The same. Form II., outer side. . . . . × 6
" 3ᵃ′. The same. Form II., inner side. . . . . × 6

PLATE VIII.

First abdominal appendages of male.

Fig. 1ᵃ. Cambarus pubescens Fax. Form II. . . . . × 8
" 1ᵃ′. The same. Form II. . . . . × 8
" 2. Cambarus Alleni Fax. Form I. . . . . × 6
" 2′. The same. Form I. . . . . × 6
" 3. Cambarus simulans Fax. Form I. . . . . × 6
" 3′. The same. Form I. . . . . × 6
" 3ᵃ. The same. Form II. . . . . × 8
" 3ᵃ′. The same. Form II. . . . . × 8
" 4. Cambarus gracilis Bundy. Type. Form I. . . . . × 6
" 4′ The same. Form I. . . . . × 6
" 4″. The same. Form I. . . . . × 6
" 5. Cambarus Cubensis Erichs. Form I. . . . . × 12
" 5′. The same. Form I. . . . . × 12
" 5ᵃ. The same. Form II. . . . . × 12
" 5ᵃ′. The same. Form II. . . . . × 12
" 6ᵃ Cambarus acuminatus Fax. Form II. . . . . × 12
" 6ᵃ′. The same. Form II. . . . . × 12
" 7. Cambarus dubius Fax. Form I. . . . . × 6
" 7′. The same. Form I. . . . . × 6
" 8. Cambarus Uhleri Fax. Form I. . . . . × 8
" 8′. The same. Form I. . . . . × 8
" 8ᵃ. The same. Form II. . . . . × 12
" 8ᵃ′. The same. Form II. . . . . × 12

PLATE IX.

First abdominal appendages of male.

Fig. 1ª. Cambarus hamulatus Fax. Form II. × 12
" 1′. The same. Form II. × 12
" 2ª. Cambarus Girardianus Fax. Form II. × 10
" 2′. The same. Form II. × 10
" 3. Cambarus cornutus Fax. Form I. × 6
" 3′ The same. Form I. × 6
" 4. Cambarus medius Fax.* Form I. × 6
" 4′. The same. Form I. × 6
" 5. Cambarus forceps Fax. Form I. × 8
" 5′. The same. Form I. × 8
" 5ª. The same. Form II. × 8
" 5′. The same. Form II. × 8
" 6 Cambarus Putnami Fax. Form I. × 4½
" 6′. The same. Form I. × 4½
" 6ª. The same. Form II. × 8
" 6′. The same. Form II. × 8
" 7. Cambarus spinosus Bundy? Lauderdale Co., Ala. Form I. × 6
" 7′ The same. Form I. × 6
" 7ª. Cambarus spinosus Bundy. Etowah River, Ga. Form II. × 4
" 7′. The same. Form II. × 4
" 8. Cambarus rusticus Gir. Yellow Springs, Ohio. Form I. × 6
" 8′. The same. Form I. × 6
" 8ª. The same. Form II. × 6
" 8′. The same. Form II. × 6
" 9. Cambarus Harrisonii Fax. Form I. × 6
" 9′. The same. Form I. × 6
" 10. Cambarus propinquus, var. Sanbornii Fax. Form I. × 5
" 10′. The same. Form I. × 5
" 10ª. The same. Form II. × 6
" 10′. The same. Form II. × 6

PLATE X.

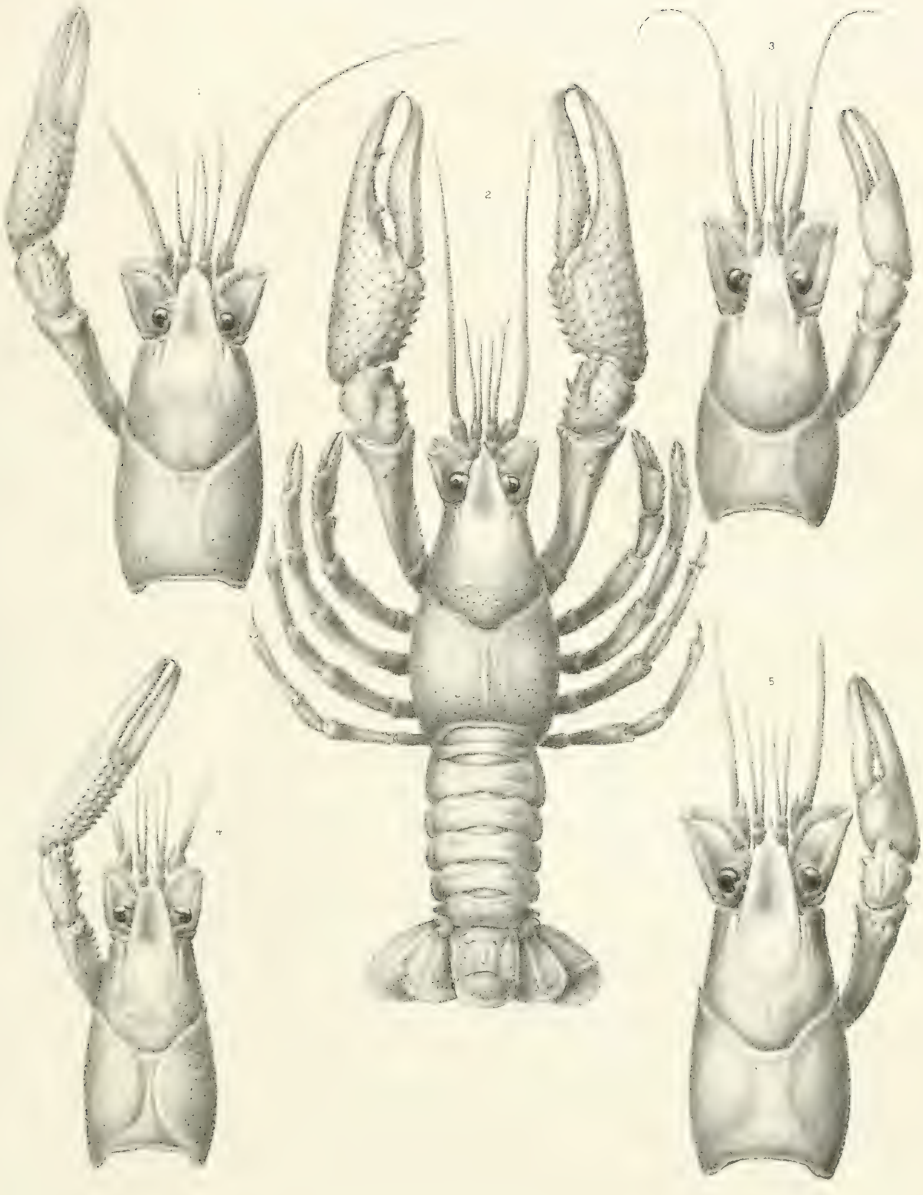
First abdominal appendages of male.

Fig. 1. Cambarus Sloanii Bundy. Form I. × 6
" 1′ The same. Form I. × 6
" 1ª. The same. Form II. × 8
" 1′. The same. Form II. × 8
" 2. Cambarus compressus Fax. Form I. × 8
" 2′. The same. Form I. × 8
" 2ª. The same. Form II. × 12
" 2′ The same. Form II. × 12
" 3 Cambarus Alabamensis Fax. Form I. × 6
" 3′ The same. Form I. × 6
" 3ª. The same. Form II. × 6
" 3′. The same. Form II. × 6
" 4. Cambarus Mississippiensis Fax. Form I. × 6
" 4′. The same. Form I. × 6
" 4ª The same. Form II. × 6
" 4′. The same. Form II. × 6

* The outer ramus was warped by drying when the specimen was in the artist's hands.

Fig. 5ª. Cambarus Palmeri Fax. Form II. . . . . × 6
" 5ª′. The same. Form II. . . . . × 6
" 6ª Cambarus immunis Hag. Form II. . . . . × 6
" 6ª′. The same. Form II. . . . . × 6
" 7. Cambarus Montezumæ Saus. Form I. . . . . × 20
" 7′. The same. Form I. . . . . × 20
" 7ª. The same. Form II. . . . . × 16
" 7ª′. The same. Form II. . . . . × 16
" 8. Cambarus Shufeldtii Fax. Form I. . . . . × 25
" 8′. The same. Form I. . . . . × 25
" 8ª. The same. Form II.* . . . . . × 30
" 8ª′. The same. Form II. . . . . × 30
" 9. Astacus (Cambaroides) Dauricus Fax. . . . . × 6
" 9′. The same. . . . . × 6
" 10. Astacus (Cambaroides) Japonicus Fax. . . . . × 8
" 10′. The same. . . . . × 8

* The distinction between form I. and form II. is not well shown in these figures. Compare the description on page 124.



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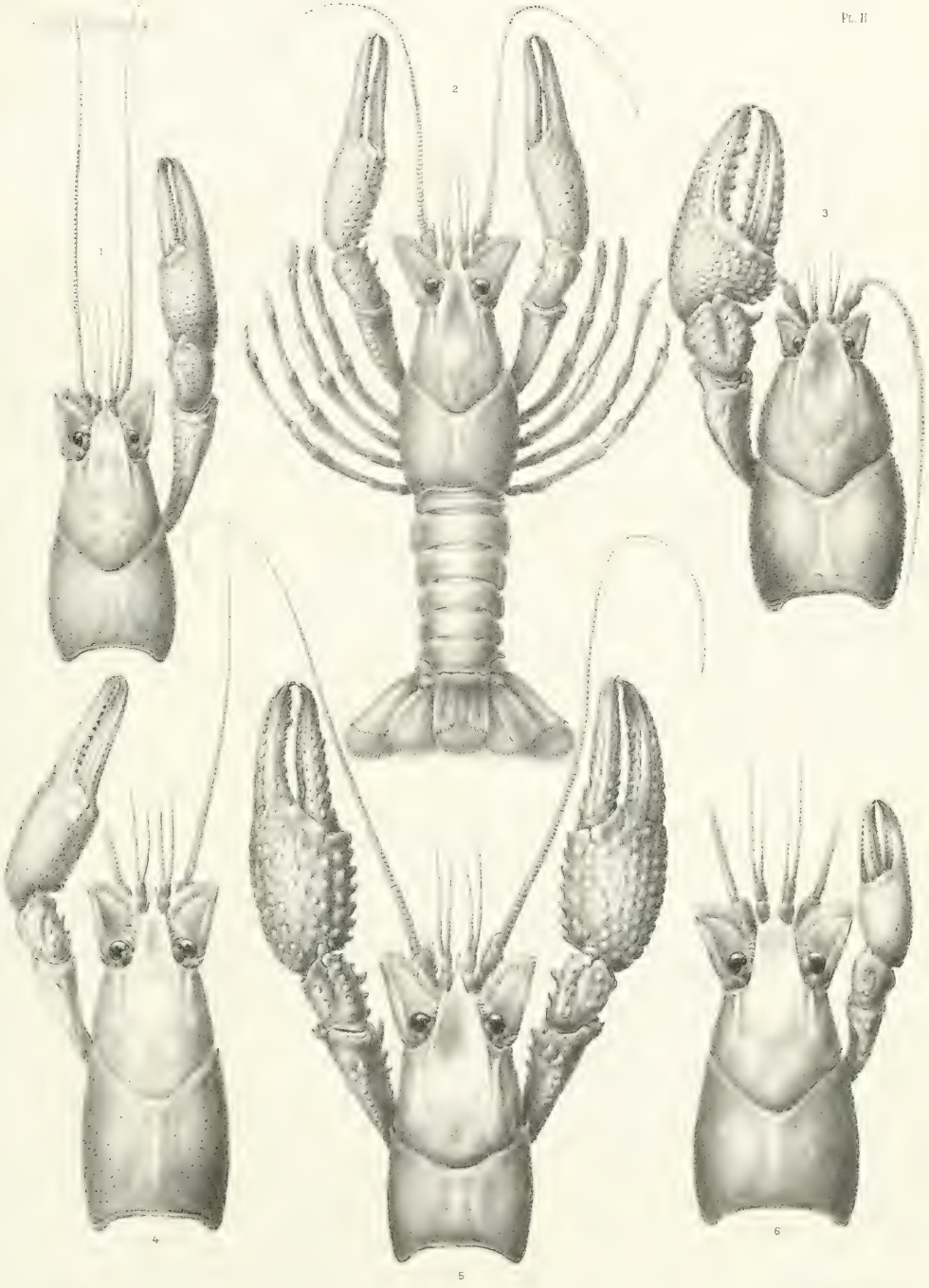
5. C. IMMUNIS, VAR. SPINIROSTRIS



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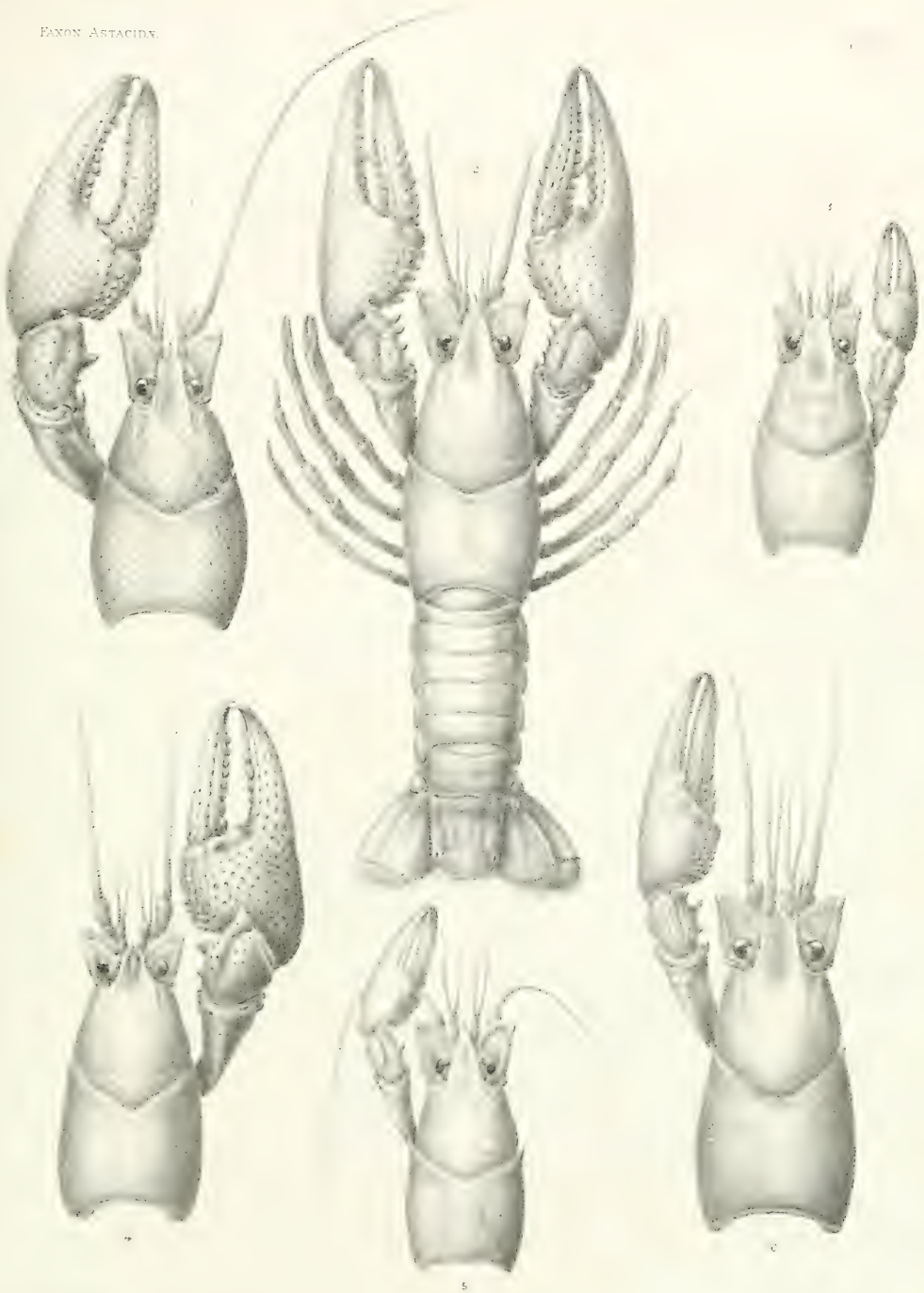

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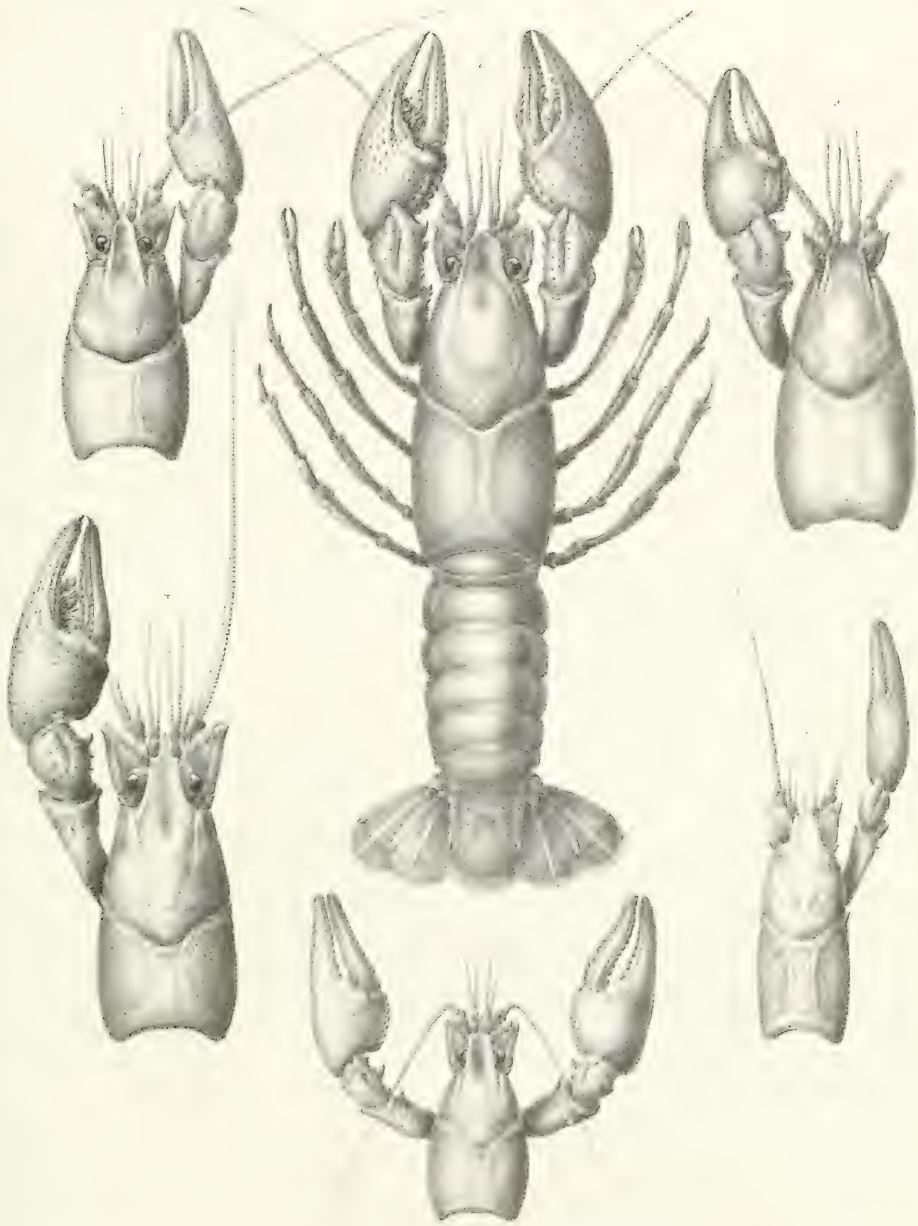
5. C. ACUMINATUS. 6. C. PALMERI.



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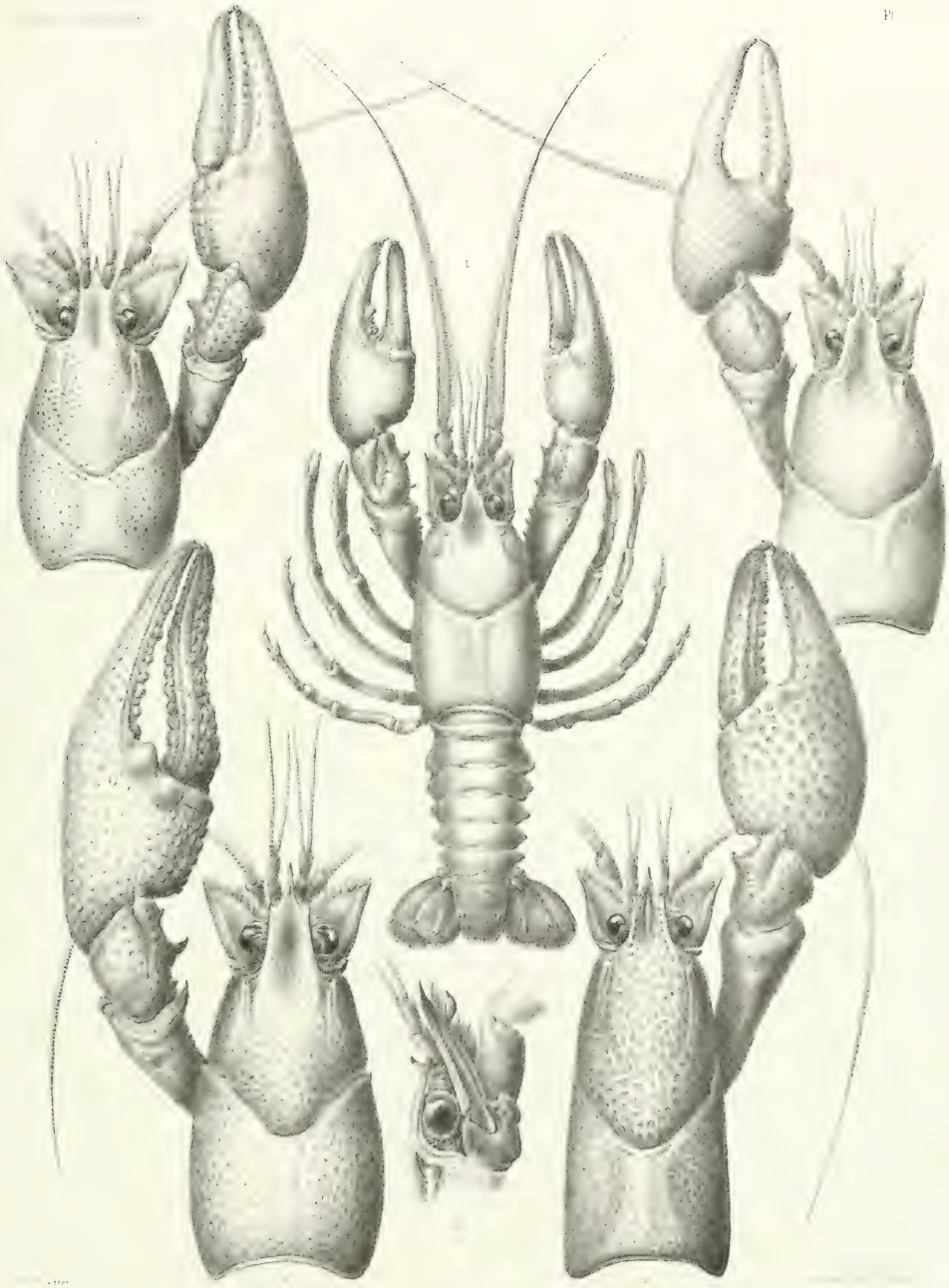

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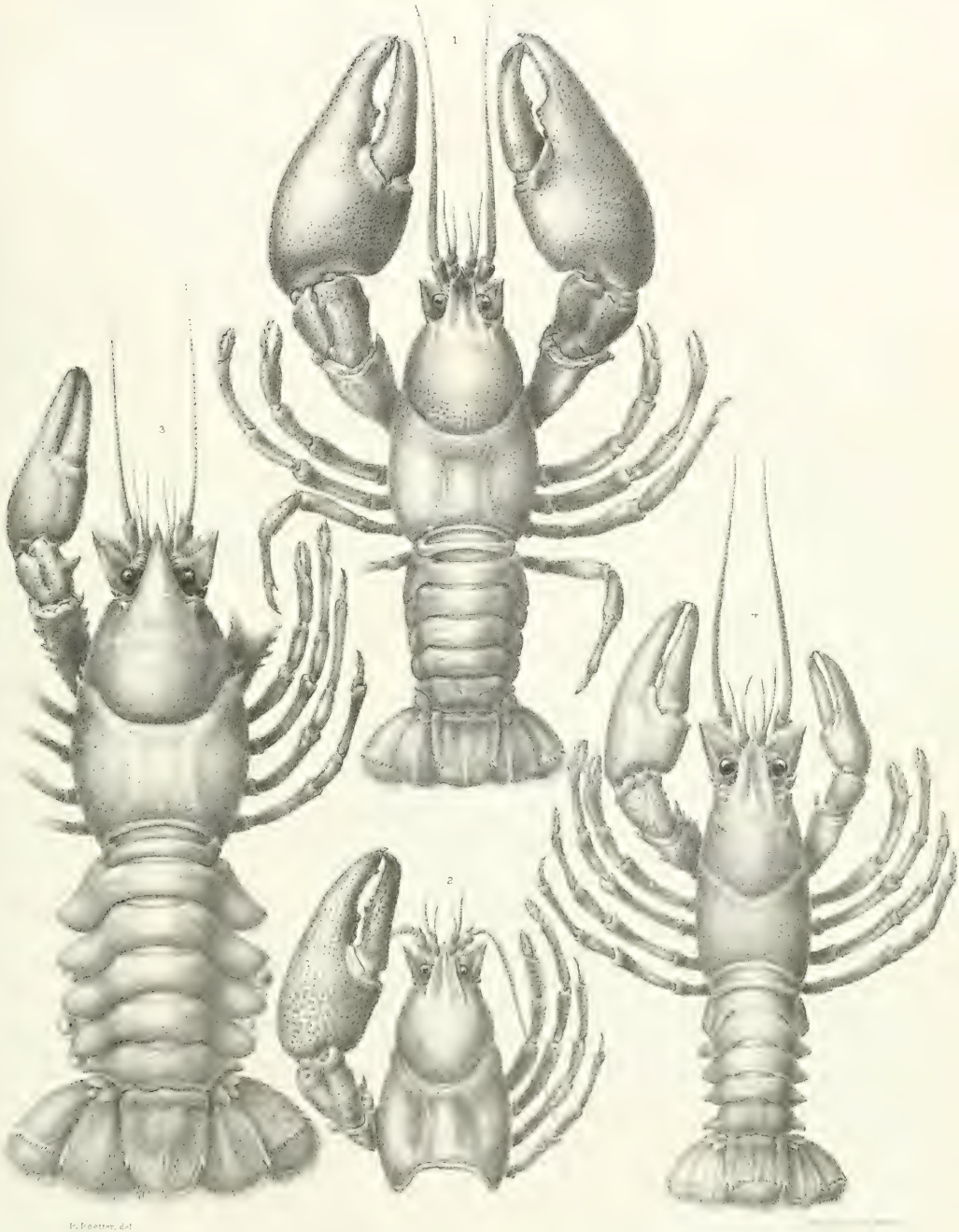

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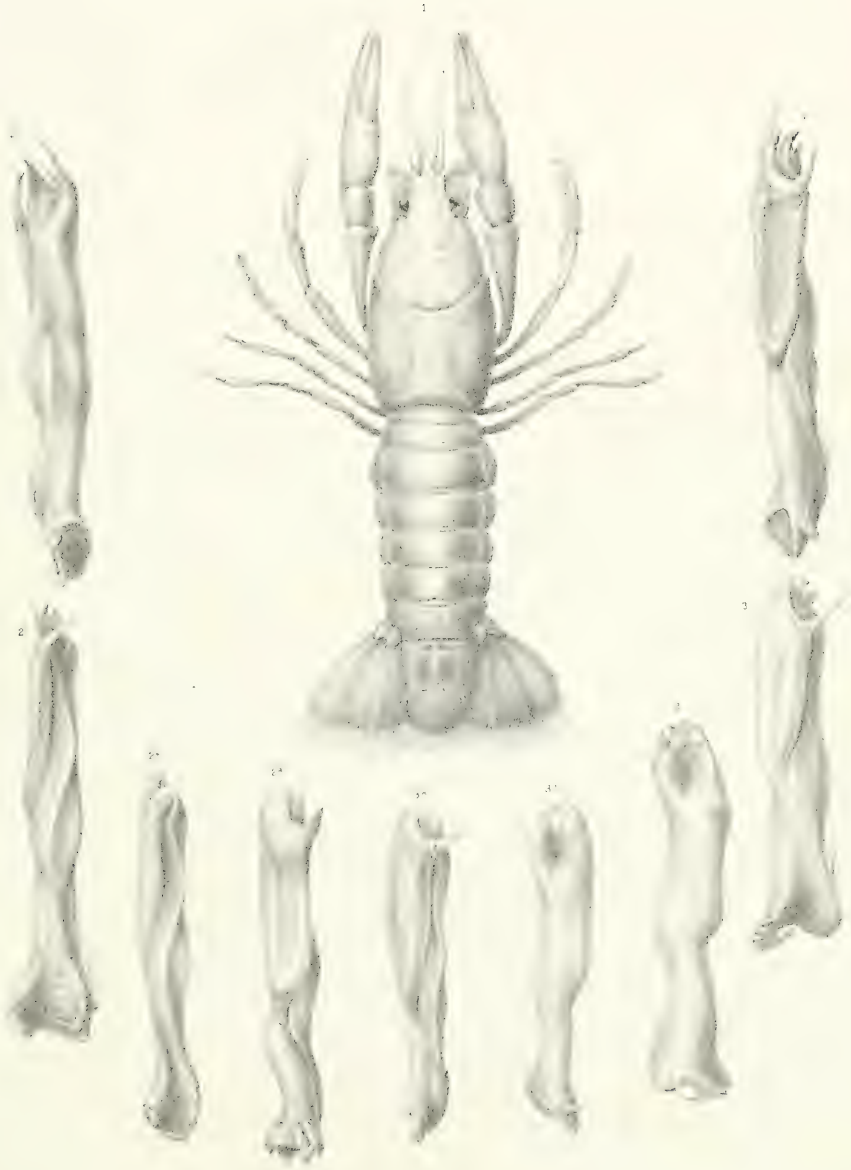

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